DOCUMENT RESUME

ED 190 360 SE 031 304

AUTHOR	Bonar, John R., Ed.: Hathway, James A., Ed.
TITLE	Probing the Natural World, Level III, Student Guide: Environmental Science. Intermediate Science Curriculum Study.
INSTITUTION	Florida State Univ., Tallahassee. Dept. of Science Education.
SPONS AGENCY	National Science Foundation, Washington, D.C.: Office of Education (DHEW), Washington, D.C.
PUB DATE	72
NOTE	160p.: For related documents, see SE 031 300-330, ED 035 559-560, ED 049 032, and ED 052 940. Contains photographs and colored and shaded drawings and print which may not reproduce well.
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	Environmental Education: Grade 9: *Individualized Instruction: Industry: Instructional Materials: Junior High Schools: *Laboratory Manuals: Laboratory Procedures: Natural Resources: *Science Activities: Science Course Improvement Projects; Science Education: Secondary Education: Secondary School Science: *Water Pollution
IDENTIFIERS	*Intermediate Science Curriculum Study

ABSTRACT

This is the student's edition of one of the Intermediate Science Curriculum Study (ISCS) units for level III students (grade 9). The chapters contain basic information about environmental pollution and hazards, activities related to the subject, and optional excursions. A section on introductory notes to the student discusses how to use the book and how the class will be organized. Data tables and empty spaces within the workbook format indicate where responses are expected. Illustrations accompany all instructions and the students are encouraged to select the proper equipment based on the illustrations. (SA)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED190360

SE 031 304

Environmental Science

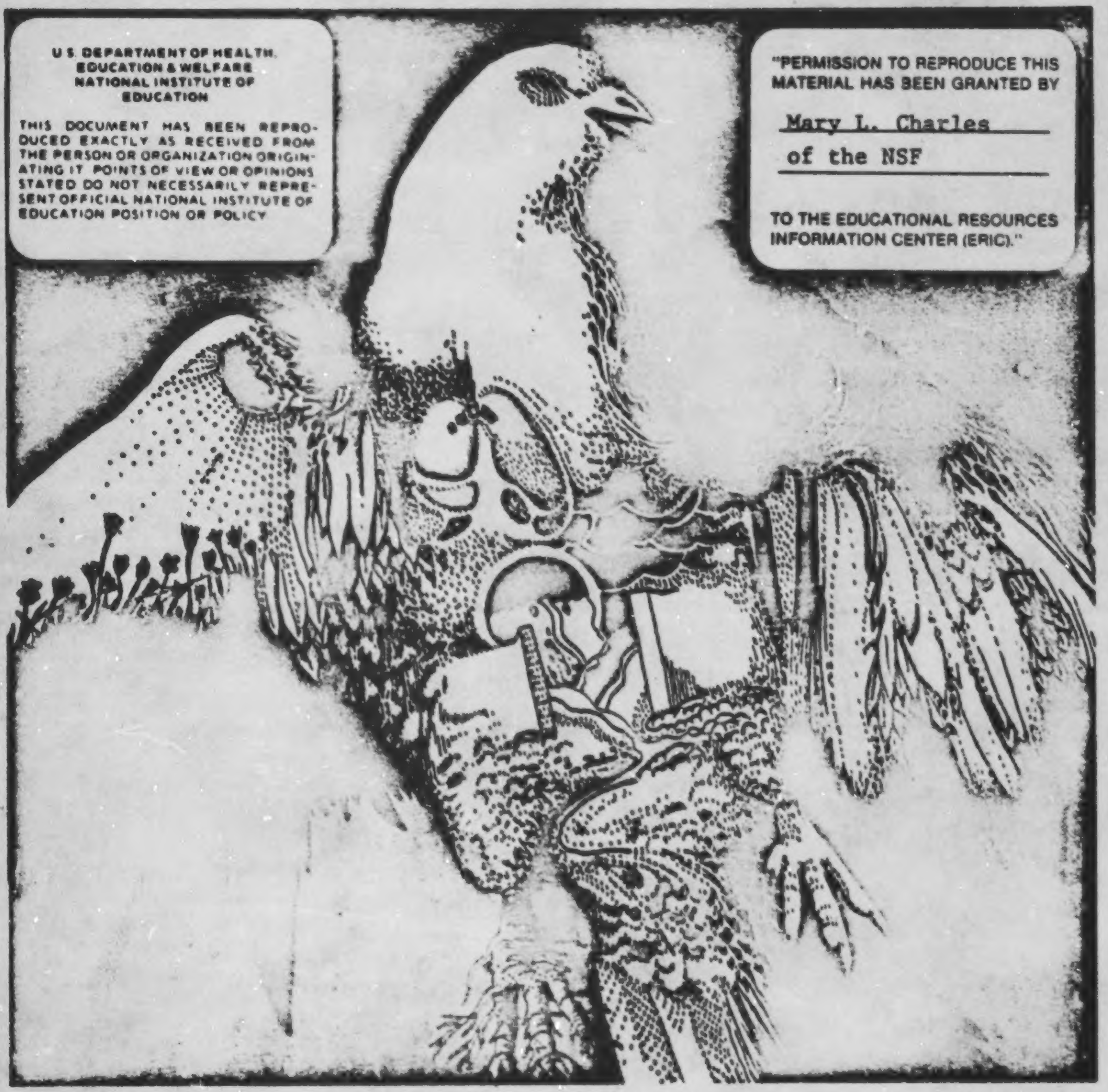
U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Mary L. Charles
of the NSF

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."



Probing the Natural World/3

INTERMEDIATE
SCIENCE
CURRICULUM
STUDY

THIS BOOK IS THE PROPERTY OF:

STATE ____________________
PROVINCE ____________________
COUNTY ____________________
PARISH ____________________
SCHOOL DISTRICT ____________________
OTHER ____________________

Book No. __________
Enter information
in spaces
to the left as
instructed

ISSUED TO	*Year Used*	*CONDITION*	
		ISSUED	*RETURNED*

PUPILS to whom this textbook is issued must not write on any page or mark any part of it in any way, consumable textbooks excepted.

1. Teachers should see that the pupil's name is clearly written in ink in the spaces above in every book issued.
2. The following terms should be used in recording the condition of the book: New; Good; Fair; Poor; Bad.

INTERMEDIATE SCIENCE CURRICULUM STUDY

Environmental Science

Probing the Natural World / Level III

SILVER BURDETT
GENERAL LEARNING CORPORATION
Morristown, New Jersey · Park Ridge, Ill. · Palo Alto · Dallas · Atlanta

ISCS PROGRAM

LEVEL I **Probing the Natural World** / Volume 1 / with Teacher's Edition
Student Record Book / Volume 1 / with Teacher's Edition
Master Set of Equipment / Volume 1
Test Resource Booklet

LEVEL II **Probing the Natural World** / Volume 2 / with Teacher's Edition
Record Book / Volume 2 / with Teacher's Edition
Master Set of Equipment / Volume 2
Test Resource Booklet

LEVEL III **Why You're You** / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
Environmental Science / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
Investigating Variation / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
In Orbit / with Teacher's Edition,
Record Book / with Teacher's Edition / **Master Set of Equipment**
What's Up? / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
Crusty Problems / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
Winds and Weather / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**
How's Your Health? / with Teacher's Edition
Record Book / with Teacher's Edition / **Master Set of Equipment**

ACKNOWLEDGMENTS

The work presented or reported herein was performed pursuant to a Contract with the U. S. Office of Education, Department of Health, Education, and Welfare. It was supported, also, by the National Science Foundation. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Office of Education or the National Science Foundation, and no official endorsement by either agency should be inferred.

© 1972 THE FLORIDA STATE UNIVERSITY

All rights reserved · Printed in the United States of America. Published simultaneously in Canada · Copyright is claimed until 1977. Except for the rights to materials reserved by others, the Publishers and the copyright owner hereby grant permission to domestic persons of the United States and Canada for use of this work without charge in the English language in the United States and Canada after 1977 provided that the publications incorporating materials covered by the copyrights contain an acknowledgment of them and a statement that the publication is not endorsed by the copyright owner. For conditions of use and permission to use materials contained herein for foreign publications in other than the English language, apply to the copyright owner. This publication, or parts thereof, may not be reproduced in any form by photographic, electrostatic, mechanical, or any other method, for any use, including information storage and retrieval, without written permission from the publisher.

ILLUSTRATIONS: © 1972 GENERAL LEARNING CORPORATION.
ALL RIGHTS RESERVED.

ISCS STAFF

David D. Redfield, *Co-Director*
William R. Snyder, *Co-Director*
Ernest Burkman, *Steering Committee Chairman*

*Laura M. Bell, *Artist*
*John R. Bonar, *Editor*
Drennan A. Browne, *Artist*
*Harold L. Buell, *Administration*
Robert L. Cocanougher, *Art Director*
*Betsy A. Conlon, *Evaluation*
Stewart P. Darrow, *Field Trial-Teacher Education*
James A. Hathway, *Editor*
*John S. Hutchinson, *Field Trial Teacher Education*
*Sally Diana Kaicher, *Art Director*
*Jane Larsen, *Art Director*
Adrian D. Lovell, *Administration*
*Audley C. McDonald, *Administration*
*W. T. Myers, *Administration*
*Lynne H. Rogers, *Artist*
Stephen C. Smith, *Artist*

ISCS ADVISORY COMMITTEE

J. Myron Atkin, *University of Illinois*
Betsy Conlon Balzano, *State University of New York College at Brockport*
Werner A. Baum, *University of Rhode Island*
Herman Branson, *Lincoln University*
*Martha Duncan Camp, *The Florida State University*
Clifton B. Clark, *University of North Carolina at Greensboro*
Steve Edwards, *The Florida State University*
Robert M. Gagné, *The Florida State University*
Edward Haenisch, *Wabash College*
*Michael Kasha, *The Florida State University*
Russell P. Kropp, *The Florida State University*
J. Stanley Marshall, *The Florida State University*
William V. Mayer, *University of Colorado*
Herman Parker, *University of Virginia*
Craig Sipe, *State University of New York at Albany*
*Harry Sisler, *University of Florida*
Clifford Swartz, *State University of New York at Stony Brook*
Claude A. Welch, *Macalester College*
Gates Willard, *Manhasset Junior High School, Manhasset, N.Y.*
Herbert Zim, *Science Writer, Tavernier, Florida*

** Former member*

MATERIALS DEVELOPMENT CONTRIBUTORS

This list includes writing-conference participants and others who made significant contributions to the materials, including text and art for the experimental editions.

Janet Anderson, *Nyack, N.Y.* Gerald R. Bakker, *Earlham College.* Frank Balzano, *F.S.U.* Harald N. Bliss, *Mayville State College.* Olaf A. Boedtker, *Oregon State Univ.* Calvin E. Bolin, *F.S.U.* Earl Brakken, *Two Harbors, Minn.* Bobby R. Brown, *F.S.U.* Robert J. Callahan, Jr. (*deceased*). Brian W. Carss, *University of Illinois.* Lois H. Case, *Lombard, Ill.* Clifton B. Clark, *University of North Carolina at Greensboro.* Sara P. Craig, *F.S.U.* John D. Cunningham, *Keene State College.* David H. Dasenbrock, *F.S.U.* Doris Dasenbrock, *F.S.U.* Jeff C. Davis, *University of South Florida.* Alan D. Dawson, *Dearborn Public Schools, Mich.* George O. Dawson, *F.S.U.* Gerrit H. DeBoer, *F.S.U.* Howard E. DeCamp, *Glenn Ellyn, Ill.* James V. DeRose, *Newtown Square, Pa.* William A. Deskin, *Cornell College.* William K. Easley, *Northeast Louisiana State College.* Donald C. Edinger, *University of Arizona.* Camillo Fano, *University of Chicago Laboratory School.* Ronald A. Fisher, *Maquoketa, Iowa.* Edwin H. Flemming, *F.U.S.* Paul K. Flood, *F.S.U.* Harper W. Frantz, *Pasadena City College* (*Emeritus*). Earl Friesen, *San Francisco State College.* Bob Galati, *Fullerton, Calif.* J. David Gavenda, *The University of Texas.* Charles A. Gilman, *Winchester, N.H.* Robert J. Goll, *Jacksonville University.* Ralph H. Granger, Jr., *Walpole, N.H.* H. Winter Griffith, *F.S.U.* William Gunn, *Miami, Florida.* John Hart, *Xavier University.* John R. Hassard, *Georgia State University.* J. Dudley Herron, *Purdue University.* Father Francis Heyden, S.J., *Georgetown University.* Leonard Himes, *Sarasota, Florida.* Evelyn M. Hurlburt, *Montgomery Junior College.* John R. Jablonski, *Boston University.* Bert M. Johnson, *Eastern Michigan University.* Roger S. Jones, *University of Minnesota.* Leonard A. Kalal, *Colorado School of Mines.* Theodore M. Kellogg, *University of Rhode Island.* Elizabeth A. Kendzior, *University of Illinois.* F. J. King, *F.S.U.* David Klasson, *Millville, Calif.* Ken Kramer, *Wright State University.* Willian H. Long, *F.S.U.* Robert Lepper, *California State College.* Harold G. Liebherr, *Milwaukee, Wis.* William D. Larson, *College of St. Thomas.* Mable M. Lund, *Beaverton, Oregon.* H. D. Luttrell, *North Texas State University.* Maxwell Maddock, *F.S.U.* Solomon Malinsky, *Sarasota, Florida.* Eloise A. Mann, *Sarasota, Florida.* Harleen W. McAda, *University of California at Santa Barbara.* Auley A. McAuley, *Michigan State University.* E. Wesley McNair, *F.S.U.* Marilyn Miklos, *F.S.U.* Floyd V. Monaghan, *Michigan State University.* Rufus F. Morton, *Westport, Conn.* Tamson Myer, *F.S.U.* Gerald Neufeld, *F.S.U.* James Okey, *University of California.* Lawrence E. Oliver, *F.S.U.* Larry O'Rear, *Alice, Texas.* Herman Parker, *University of Virginia.* Harry A. Pearson, *Western Australia.* James E. Perham, *Randolph-Macon Woman's College.* Darrell G. Phillips, *University of Iowa.* Howard Pierce, *F.S.U.* David Poché, *F.S.U.* Charles O. Pollard, *Georgia Institute of Technology.* Glenn F. Powers, *Northeast Louisiana State College.* Ernest Gene Preston, *Louisville, Ky.* Edward Ramey, *F.S.U.* Earl R. Rich, *University of Miami.* John Schaff, *Syracuse University.* Carroll A. Scott, *Williamsburg, Iowa.* Earle S. Scott, *Ripon College.* Thomas R. Spalding, *F.S.U.* Michael E. Stuart, *University of Texas.* Sister Agnes Joseph Sun, *Marygrove College.* Clifford Swartz, *State University of New York.* Thomas Teates, *F.S.U.* Bill W. Tillery, *University of Wyoming.* Ronald Townsend, *University of Iowa.* Mordecai Treblow, *Bloomsburg State College.* Henry J. Triezenberg, *National Union of Christian Schools.* Paul A. Vestal, *Rollins College.* Robert L. Vickery, *Western Australia.* Frederick B. Voight, *F.S.U.* Claude A. Welch, *Macalester College.* Paul Westmeyer, *F.S.U.* Earl Williams, *University of Tampa.* G. R. Wilson, Jr., *University of South Alabama.* Harry K. Wong, *Atherton, California.* Charles M. Woolheater, *F.S.U.* Jay A. Young, *King's College.* Victor J. Young, *Queensborough Community College.*

The genesis of some of the ISCS material stems from a summer writing conference in 1964. The participants were:

Frances Abbott, *Miami-Dade Junior College.* Ronald Atwood, *University of Kentucky.* George Assousa, *Carnegie Institute.* Colin H. Barrow, *University of West Indies.* Peggy Bazzel, *F.S.U.* Robert Binger (deceased). Donald Bucklin, *University of Wisconsin.* Martha Duncan Camp, *F.S.U.* Roy Campbell, *Broward County Board of Public Instruction, Fla.* Bruce E. Cleare, *Tallahassee Junior College.* Ann-cile Hall, *Pensacola, Florida.* Charles Holcolmb, *Mississippi State College.* Robert Kemman, *Mt. Prospect, Ill.* Gregory O'Berry, *Coral Gables, Florida.* Elra Palmer, *Baltimore.* James Van Pierce, *Indiana University Southeast.* Guenter Schwarz, *F.S.U.* James E. Smeland, *F.S.U.* C. Richard Tillis, *Pine Jog Nature Center, Florida.* Peggy Wiegand, *Emory University.* Elizabeth Woodward, *Augusta College.* John Woolever, *Sarasota, Florida.*

Foreword

A pupil's experiences between the ages of 11 and 16 probably shape his ultimate view of science and of the natural world. During these years most youngsters become more adept at thinking conceptually. Since concepts are at the heart of science, this is the age at which most students first gain the ability to study science in a really organized way. Here, too, the commitment for or against science as an interest or a vocation is often made.

Paradoxically, the students at this critical age have been the ones least affected by the recent effort to produce new science instructional materials. Despite a number of commendable efforts to improve the situation, the middle years stand today as a comparatively weak link in science education between the rapidly changing elementary curriculum and the recently revitalized high school science courses. This volume and its accompanying materials represent one attempt to provide a sound approach to instruction for this relatively uncharted level.

At the outset the organizers of the ISCS Project decided that it would be shortsighted and unwise to try to fill the gap in middle school science education by simply writing another textbook. We chose instead to challenge some of the most firmly established concepts about how to teach and just what science material can and should be taught to adolescents. The ISCS staff have tended to mistrust what authorities believe about schools, teachers, children, and teaching until we have had the chance to test these assumptions in actual classrooms with real children. As conflicts have arisen, our policy has been to rely more upon what we saw happening in the schools than upon what authorities said could or would happen. It is largely because of this policy that the ISCS materials represent a substantial departure from the norm.

The primary difference between the ISCS program and more conventional approaches is the fact that it allows each student to travel at his own pace, and it permits the scope and sequence of instruction to vary with his interests, abilities, and background. The ISCS writers have systematically tried to give the student more of a role in deciding what he should study next and how soon he should study it. When the materials are used as intended, the ISCS teacher serves more as a "task easer" than a "task master." It is his job to help the student answer the questions that arise from his own study rather than to try to anticipate and package what the student needs to know.

There is nothing radically new in the ISCS approach to instruction. Outstanding teachers from Socrates to Mark Hopkins have stressed the need to personalize education. ISCS has tried to do something more than pay lip service to this goal. ISCS' major contribution has been to design a system whereby an average teacher, operating under normal constraints, in an ordinary classroom with ordinary children, can indeed give maximum attention to each student's progress.

The development of the ISCS material has been a group effort from the outset. It began in 1962, when outstanding educators met to decide what might be done to improve middle-grade science teaching. The recommendations of these conferences were converted into a tentative plan for a set of instructional materials by a small group of Florida State University faculty members. Small-scale writing sessions conducted on the Florida State campus during 1964 and 1965 resulted in pilot curriculum materials that were tested in selected Florida schools during the 1965-66 school year. All this preliminary work was supported by funds generously provided by The Florida State University.

In June of 1966, financial support was provided by the United States Office of Education, and the preliminary effort was formalized into the ISCS Project. Later, the National Science Foundation made several additional grants in support of the ISCS effort.

The first draft of these materials was produced in 1968, during a summer writing conference. The conferees were scientists, science educators, and junior high school teachers drawn from all over the United States. The original materials have been revised three times prior to their publication in this volume. More than 150 writers have contributed to the materials, and more than 180,000 children, in 46 states, have been involved in their field testing.

We sincerely hope that the teachers and students who will use this material will find that the great amount of time, money, and effort that has gone into its development has been worthwhile.

Tallahassee, Florida
February 1972

The Directors
INTERMEDIATE SCIENCE CURRICULUM STUDY

Contents

NOTES TO THE STUDENT viii

CHAPTERS

1 The Black Death 1
2 Can You Match It? 7
3 Water, Water Everywhere . . . But . . . 21
4 The Undesirables 31
5 Getting All Steamed Up 45
6 Sick Air? 59
7 The Environment Throws a Curve 73
8 Facing Real Problems 83

EXCURSIONS

1-1 A Real Killer 95
2-1 Rearranging Particles 99
2-2 Bounty Hunters 105
3-1 A Drink of the Nile 109
4-1 Clean Vegetables? 113
6-1 Smoggy London Town 119
7-1 The More the Merrier? 125
7-2 Escape into Space 129
7-3 Birthday Control 137
8-1 Ssh! You're Polluting the Environment 141

Notes to the Student

The word *science* means a lot of things. All of the meanings are "right," but none are complete. *Science* is many things and is hard to describe in a few words.

We wrote this book to help you understand what science is and what scientists do. We have chosen to show you these things instead of describing them with words. The book describes a series of things for you to do and think about. We hope that what you do will help you learn a good deal about nature and that you will get a feel for how scientists tackle problems.

How is this book different from other textbooks?

This book is probably not like your other textbooks. To make any sense out of it, you must work with objects and substances. You should do the things described, think about them, and then answer any questions asked. Be sure you answer each question as you come to it.

The questions in the book are very important. They are asked for three reasons:

1. To help you to think through what you see and do.
2. To let you know whether or not you understand what you've done.
3. To give you a record of what you have done so that you can use it for review.

How will your class be organized?

Your science class will probably be quite different from your other classes. This book will let you start work with less help than usual from your teacher. You should begin each day's work where you left off the day before. Any equipment and supplies needed will be waiting for you.

Your teacher will not read to you or tell you the things that you are to learn. Instead, he will help you and your classmates individually.

Try to work ahead on your own. If you have trouble, first try to solve the problem for yourself. Don't ask your teacher for help until you really need it. Do not expect him to give you the answers to the questions in the book. Your teacher will try to help you find where and how you went wrong, but he will not do your work for you.

After a few days, some of your classmates will be ahead of you and others will not be as far along. This is the way the course is supposed to work. Remember, though, that there will be no prizes for finishing first. Work at whatever speed is best for you. *But be sure you understand what you have done before moving on.*

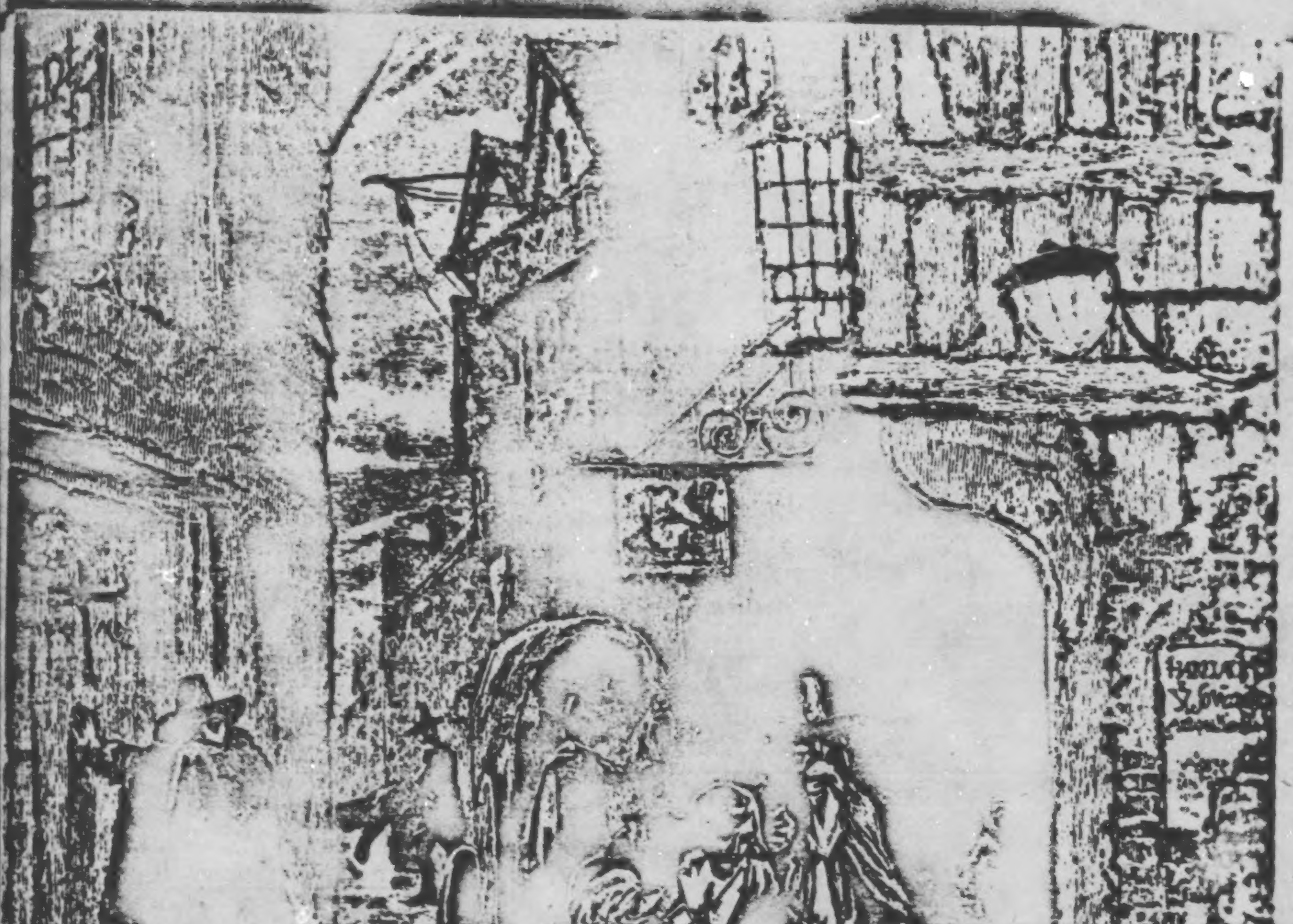
Excursions are mentioned at several places. These special activities are found at the back of the book. You may stop and do any excursion that looks interesting or any that you feel will help you. (Some excursions will help you do some of the activities in this book.) Sometimes, your teacher may ask you to do an excursion.

What am I expected to learn?

During the year, you will work very much as a scientist does. You should learn a lot of worthwhile information. More important, we hope that you will learn how to ask and answer questions about nature. *Keep in mind that learning how to find answers to questions is just as valuable as learning the answers themselves.*

Keep the big picture in mind, too. Each chapter builds on ideas already dealt with. These ideas add up to some of the simple but powerful concepts that are so important in science. If you are given a Student Record Book, do all your writing in it. *Do not write in this book.* Use your Record Book for making graphs, tables, and diagrams, too.

From time to time you may notice that your classmates have not always given the same answers that you did. This is no cause for worry. There are many right answers to some of the questions. And in some cases you may not be able to answer the questions. As a matter of fact, no one knows the answers to some of them. This may seem disappointing to you at first, but you will soon realize that there is much that science does not know. In this course, you will learn some of the things we don't know as well as what is known. Good luck!



The Black Death

Chapter 1

The Honorable Doctor Eric Robinson
Maleren Road, Staden isl.
Stockholm, Sweden

10 April, 1351

We set sail from Naples, Italy, five days ago and are en route to Barcelona, Spain. Winds are light and the weather is good. So with time to spare, I shall undertake to keep my promise to you and put my log notes in some order. Perhaps then you may make some sense of the horrible pestilence that has demolished the people of Europe and stolen so many of our dearest ones.

When we reached Marseilles, France, over three years ago in late 1347, the plague had already arrived there. The people suspected it had come by ship from Genoa. The Genoan merchant marine may have brought the disease from Kaffa, a Genoan colony on the Black Sea. Kaffa had been besieged by the Tartars. But the Tartars were finally forced to give up the siege because so many of their forces were lost to the pestilence. Before they departed, the Tartars catapulted bodies of their dead warriors into the city, hoping to spread the death among the citizens. They believed the pestilence could be transmitted from the dead to the living.

It is believed that when the Genoan sailors returned home, they brought the disease with them. It is also rumored that in addition to the disease, they brought a large number of black rats that had stowed away while their ships had been docked at Kaffa. Upon reaching the port of Genoa, the disease and, of course, the rats spread into the city.

Soon the blight spread to Marseilles. No one knew how for sure, perhaps by ship again. Some said it was spread by the miasma, or poison cloud. Corrupted air, damp mists, hot south winds have all been suspected of carrying the pestilence. Earthquakes, fire pillars, and other mysterious occurrences are considered by some to be the cause of the plague. While in Venice, a few months ago, I heard that the Venetians had received an omen of the coming plague. Just before the disease appeared in the city, an earthquake occurred and the bells in St. Mark's rang out without being touched by human hands.

Astrologers in Paris blame the catastrophe on the conjunction of Saturn, Jupiter, and Mars in the house of Aquarius. Other Parisians believed the pestilence to have been caused by a ball of fire seen above the city.

I'm sure that you, with your scientific knowledge, will be able to decide which, if any, of these explanations is best. Whatever the cause, the people I've seen all around Europe seem resigned to their fate. They agree that the pestilence is the will of God. They are sure their sins have brought this punishment upon them.

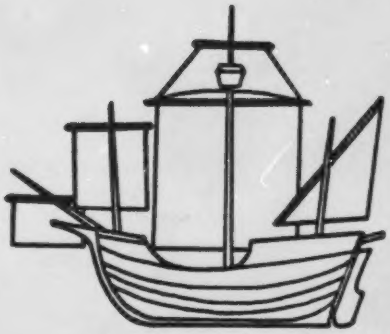
As you know, millions have died in the three years since 1347. I need not report the horrible nature of the disease. You know it too well. But how it passes from person to person is still a mystery. Some say it is by breath; others claim only a look is necessary. Just by touch it spreads, according to one theory. Some even believe it is foul air bottled up in vessels. It is said that these vessels are carried by evil men to a place upwind from a city. Then their foul contents are released and the fumes spread over the town.

It is almost unbelievable how many have died the horrible death of bursting boils and blistering fever. No one is certain of the count. It is estimated that, within six months, Florence lost 55,000 of its 90,000 inhabitants. The reports I have heard from all over Italy suggest that up to 60% of the population perished. Apparently, the same horror abounded in other countries. All in all, more than 30% of the population of Europe have died. The heaviest toll reported is among the clergy—around 50%. Some monasteries have been completely wiped out.

But my promise was to help you chart the spread of the plague. I have tabulated what figures I could get in the enclosed logs. All dates are approximate. The cities have been *identified according to the six-month period during which the disease fell upon the inhabitants. I trust this will help you in your research.*

May God live with you each day.
Your friend and brother,

Swen



The plague described briefly in this letter is perhaps the greatest environmental crisis ever to strike Europe. Later to be called the Black Death, it originated in Asia. It was not the only plague to strike. There were many before and several to follow. However, the Black Death of the fourteenth century took a dreadful toll. Nearly thirty million Europeans died.

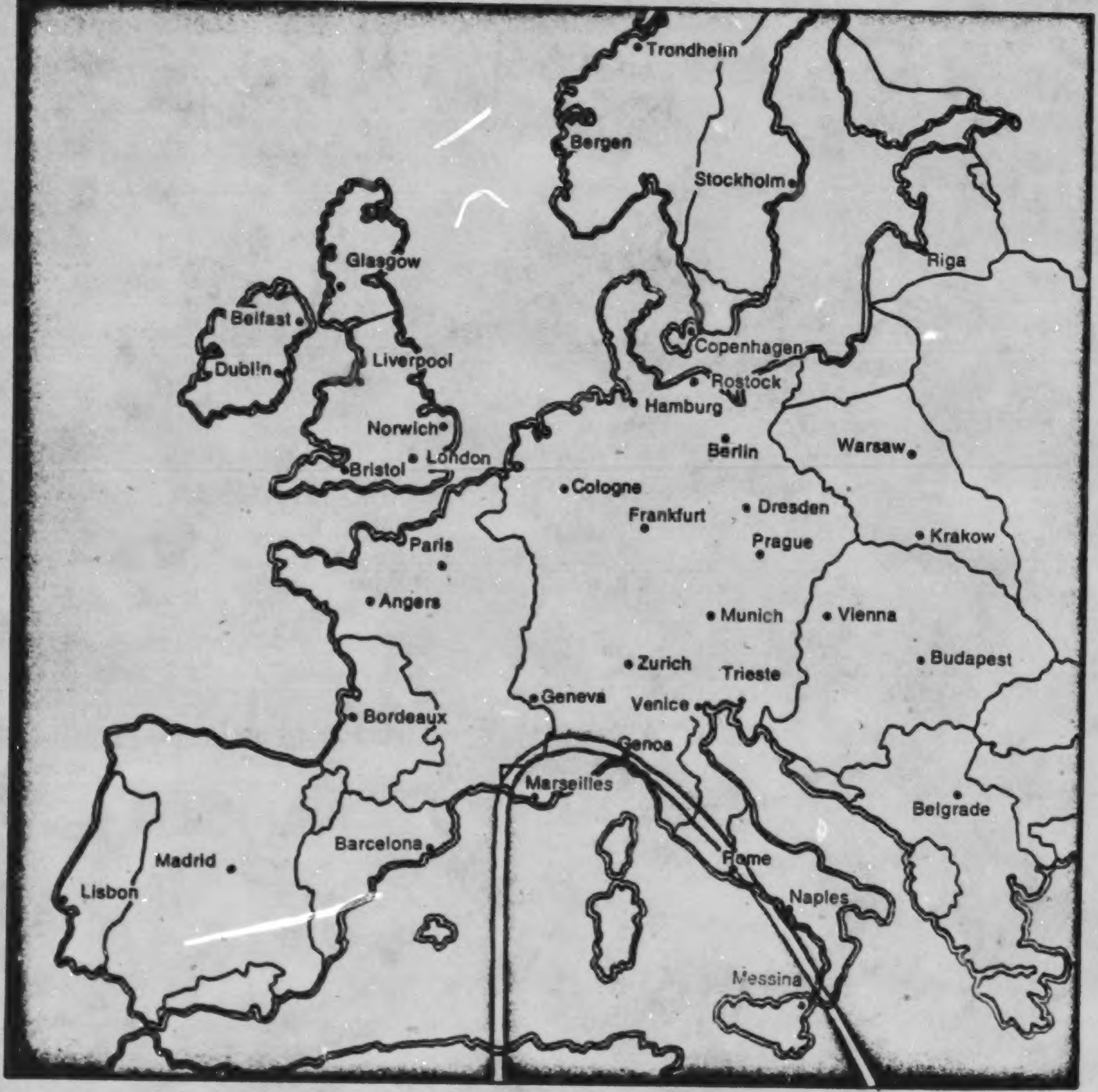
The log referred to in the letter follows in Table 1-1. Assume that you are the physician receiving these data. Use the data to chart the movement of the Black Death across Europe. (The names used in the log, as well as many in the letter, have been modernized so that they are the ones most familiar to you.)

Table 1-1

Month and Year	New Cities Affected	Month and Year	New Cities Affected
December, 1347	Genoa, Marseilles, Messina, Naples, Rome	December, 1349	Belfast, Bergen, Berlin, Dresden, Glasgow, Hamburg
June, 1348	Angers, Belgrade, Bordeaux, Geneva, Madrid, Paris, Trieste, Venice	June, 1350	North of Bergen, Copenhagen, Rostock, Warsaw
December, 1348	Bristol, Budapest, Lisbon, London, Munich, Vienna, Zurich	December, 1350	South of Riga, Stockholm, North of Trondheim
June, 1349	Cologne, Dublin, Frankfurt, Liverpool, Krakow, Norwich, Prague		

☐**1-1.** For each six-month interval, show how far the plague had spread by sketching a line of best fit across the map in Figure 1-1 of your Record Book. (Notice that a line has already been drawn for the December 1347 information.)

Figure 1-1



Trondheim
Bergen
Stockholm
Riga
Glasgow
Belfast
Dublin
Liverpool
Copenhagen
Rostock
Hamburg
Norwich
Bristol
London
Berlin
Warsaw
Cologne
Frankfurt
Dresden
Prague
Krakow
Paris
Angers
Munich
Vienna
Zurich
Trieste
Budapest
Geneva
Venice
Bordeaux
Genoa
Marseilles
Belgrade
Barcelona
Madrid
Lisbon
Rome
Naples
Messina

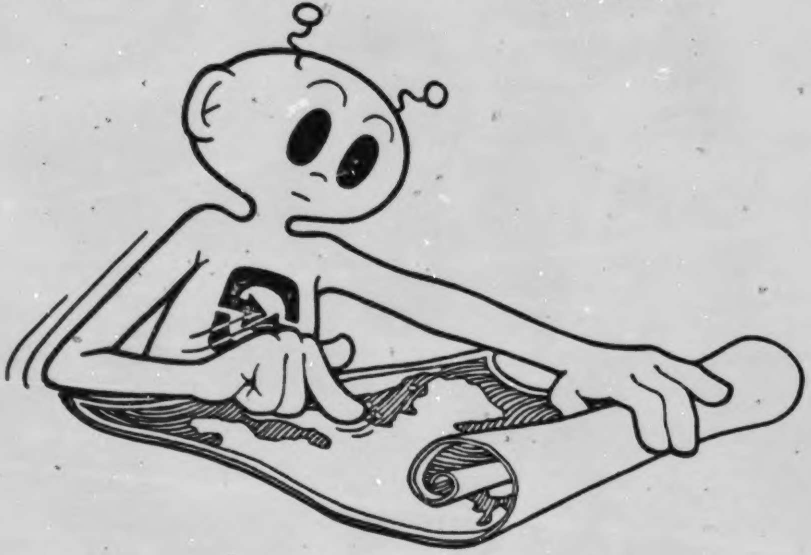
The steady march of the plague across Europe represented a great catastrophe for the people. Many countries were overpopulated, and great crop failures had brought these nations to their knees. Now a killing blow was dealt by disease. The suffering people believed their folly and sin had brought disaster down upon them. And they were not entirely wrong. Overpopulation in certain areas had produced overcrowded and unhealthy living conditions. Careless piling of rubbish provided food for increasing numbers of rats and other vermin. The people had misused their environment. They did not understand that the environment cannot be misused indefinitely.

Since the fourteenth century, man has learned to control the spread of the plague by using special drugs and vaccines. However, man has much to learn about his environment. He is just beginning to see that his living habits can make this world unsafe and unfit for life. This unit, *Environmental Science,* can help you better understand how your actions influence the world in which you live.

If you'd like to find out more about the cause and effects of the Black Death, do **Excursion 1-1,** "A Real Killer." It's a good chance to see if you remember how to plot data on a grid and how to read the graph, too.

◀**EXCURSION**

Before going on, do Self-Evaluation 1 in your Record Book.



Can You Match It?

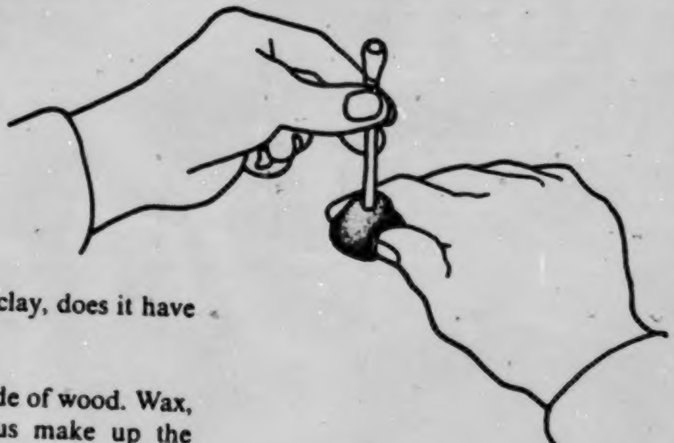
Chapter 2

Most people believe they have little if any effect on what happens in their surroundings. They think they have no influence on anything. Are these people right, or wrong? You can see for yourself. From the supply table, get the following:

- 1 friction match
- 1 small piece of sandpaper
- 1 lump of clay

In a few minutes, you will observe the match as it burns. But first, you should prepare for your observations.

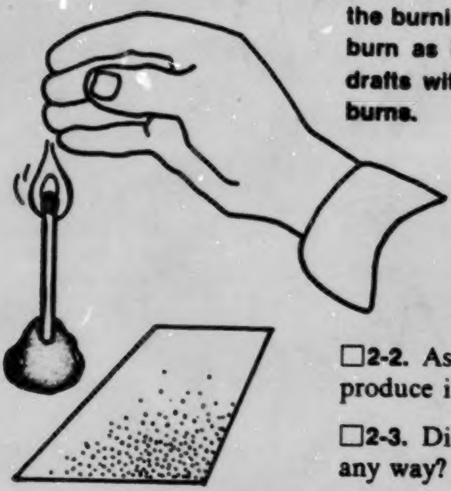
ACTIVITY 2-1. Stand the match in the lump of clay. Take a close look at it even though you have seen matches many times.



☐**2-1.** As the match stands in the lump of clay, does it have any effect on its surroundings?

The stick part of the friction match is made of wood. Wax, potassium chlorate, sulfur, and phosphorus make up the head.

ACTIVITY 2-2. Strike the match on the sandpaper and stand the burning match once more in the lump of clay. Allow it to burn as long as possible. You may need to shield it from drafts with your hand or a book. Observe it carefully as it burns.



☐**2-2.** As the match burned, what changes, if any, did it produce in the surroundings?

☐**2-3.** Did any of the changes you observed affect you in any way?

The burning of a match is a very common occurrence. It may appear to be unimportant, but is it really? Suppose you look at it from a chemist's point of view.

☐**2-4.** What evidence do you have that chemical changes were taking place as the match burned?

If you had trouble with question 2-4, it may be because you don't recall what is meant by "chemical change." The following Checkup will help you decide whether you need to study this idea before going ahead.

CHECKUP

In your Record Book, place a check by the letter of each statement that is correct.

1. During a chemical change,
   - **a.** starting materials called reactants are changed to new substances called products.
   - **b.** energy changes occur.
   - **c.** temperature and concentration of reactants can affect the rate of change.
   - **d.** a gas is always formed.
2. The ISCS particle model for matter includes the idea that

a. all matter is composed of particles called atoms.
b. there are about 1,000 different kinds of atoms.
c. atoms may combine with each other and be held together by electrical forces.
d. neutral combinations of two or more atoms contain equal amounts of positive and negative charge.

3. As a chemical reaction occurs,
  a. atoms in reactants are destroyed.
  b. reactant atoms are rearranged into new combinations called products.
  c. energy is needed to overcome the forces holding reactant atoms together.

Turn to page 99 in **Excursion 2-1** to check your answers.

◀ **EXCURSION**

☐**2-5.** Recall the procedure you used when lighting the match. What did you have to do?

As you know, the name given to the match you used is "friction match." If you remember your early work in ISCS, you know something about friction.

☐**2-6.** What form of energy is associated with friction?

To get your match started, you had to warm it up. You did this by striking (rubbing) it against a rough surface. This friction produced heat. All the match needed was heat and the oxygen in the surrounding air to get started.

☐**2-7.** What *products* resulted from the burning of the match?

Suppose the entire match burned. A chemist's simple statement about the chemical change you've observed might be this:

MATCH + AIR + HEAT → ASH + SMOKE + ENERGY

You supply heat by rubbing the match on the sandpaper. The heated substances in the match head combine with oxygen from the air to form new products. For example:

Phosphorus + Oxygen → Phosphorus oxide
Sulfur + Oxygen → Sulfur oxide

The ash that is produced during the burning is composed mostly of carbon and other unburned solids. The ash is the remains of the match. The smoke is a combination of gases and very tiny particles of solids carried up by the hot gases. One of the gases produced is carbon dioxide, a substance you know a lot about if you studied Volume 2 of ISCS. The wax and wood of the match contain hydrogen, in addition to carbon.

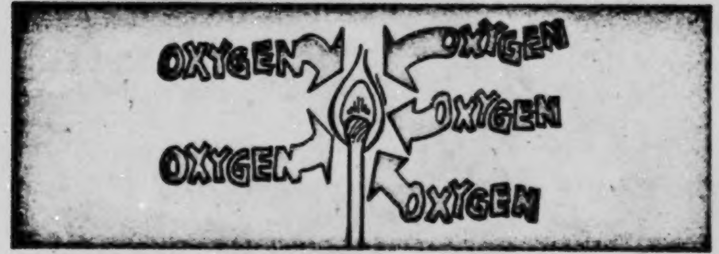
☐**2-8.** When hydrogen (H) combines with oxygen (O), what product is formed?

☐**2-9.** A very important product of the burning is energy. What forms of energy did you observe during the burning?

You can see that when a simple match burns, some very complicated things happen. In fact, a complete description of all the changes would be very complicated indeed. However, the important thing is the fact that the burning match changes its own surroundings. It does this in two basic ways.

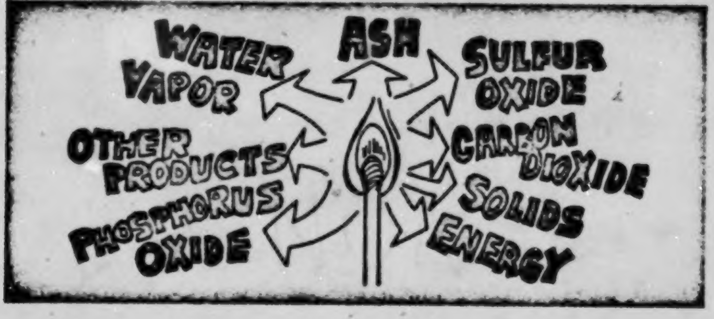
First, the burning match takes something away from its surroundings.

Figure 2-1


OXYGEN
OXYGEN
OXYGEN
OXYGEN
OXYGEN

And second, the burning match adds things to its surroundings.

Figure 2-2


WATER VAPOR
ASH
SULFUR OXIDE
OTHER PRODUCTS
CARBON DIOXIDE
PHOSPHORUS OXIDE
SOLIDS
ENERGY

It helps to think of the match and the surrounding air as a system. You may recall that a *system* is a set of things that influence each other. In other words, a system is a set of things that have some effect on each other.

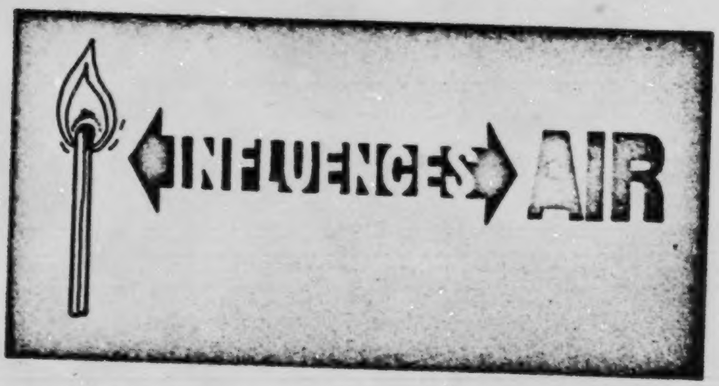


Figure 2-3

The things that make up a system are called *components.* The match and the surrounding air may be thought of as the components of a system. Figure 2-4 illustrates what happens in this system as the match burns.

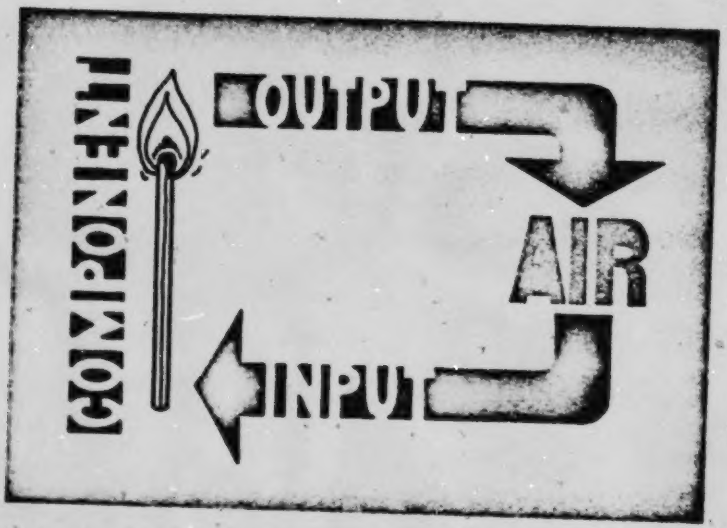


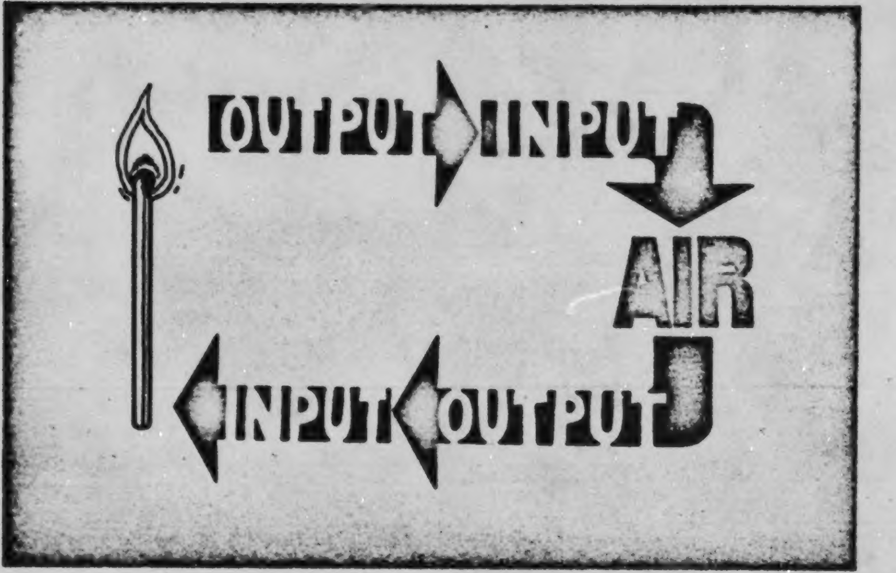
Figure 2-4

As the match burns, it releases certain products into the air. These products are its output.

☐**2-10.** What is the input to the match from the air?

The match's total output includes all the products it gives to its surroundings. Most of the match's output goes into the surrounding air. This output of heat, gases, and solid particles changes the surrounding air. The air's input of oxygen to the match is necessary for it to burn. This input causes great changes in the match. Figure 2-5 illustrates the idea that output for one component is input for the other.

Figure 2-5



In the first paragraph of this chapter, you were told that most people believe they have no important influence on their surroundings. Your activities have shown that something as simple as a friction match can change its own environment and, in turn, be changed itself. Do people match up? Do the effects of people and other living things on their surroundings compare to those of a burning match?

☐**2-11.** Are you having any influence at this moment on your surroundings?

Think of yourself and the surrounding air as components of a system. Remember that components influence each other. Figure 2-6 of your Record Book suggests that an input-output exchange is occurring between you and the air right now.

☐**2-12.** In Figure 2-6 of your Record Book, list under the proper heading those things being exchanged between you and the air. Then have your teacher check your work before going ahead.

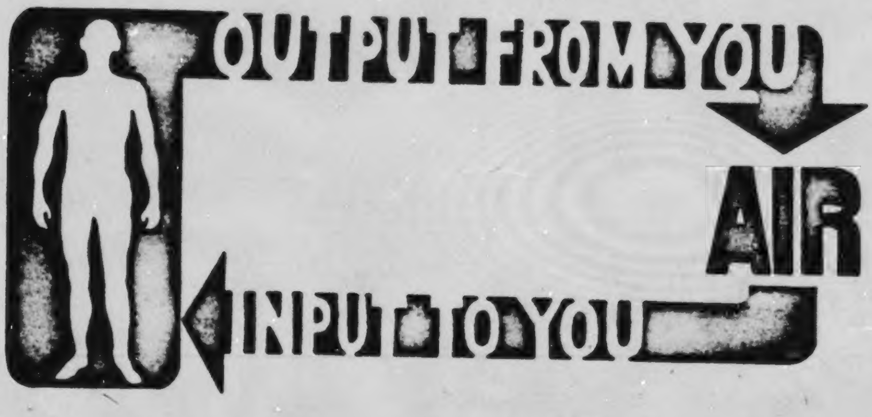


Figure 2-6

As you take in oxygen from the air and release CO_2 and heat, you produce important changes in your surroundings. You increase the temperature. You increase the amount of CO_2 in the air around you, and you decrease the amount of oxygen. These changes occur even when you sit quietly. You really do influence your surroundings. But how can one person's effect be important?

☐**2-13.** Suppose everyone in your room struck one match at the same time. Would the heat, smoke, and odor produced make a noticeable change in the room?

The small effect that each person has on changing the surroundings may at first seem unimportant, just as the effect of one match seems so small. But combining many small effects can produce great changes in the environment. One person all alone may have little effect on his world. But the total effects of many persons living close together can be disastrous for their surroundings.

Living things have an important effect on their surroundings. All creatures and plants have a set of input-output needs. Each one must take in certain solids, liquids, and gases. And each one must have the energy it needs to change these raw materials into chemicals its body can use.

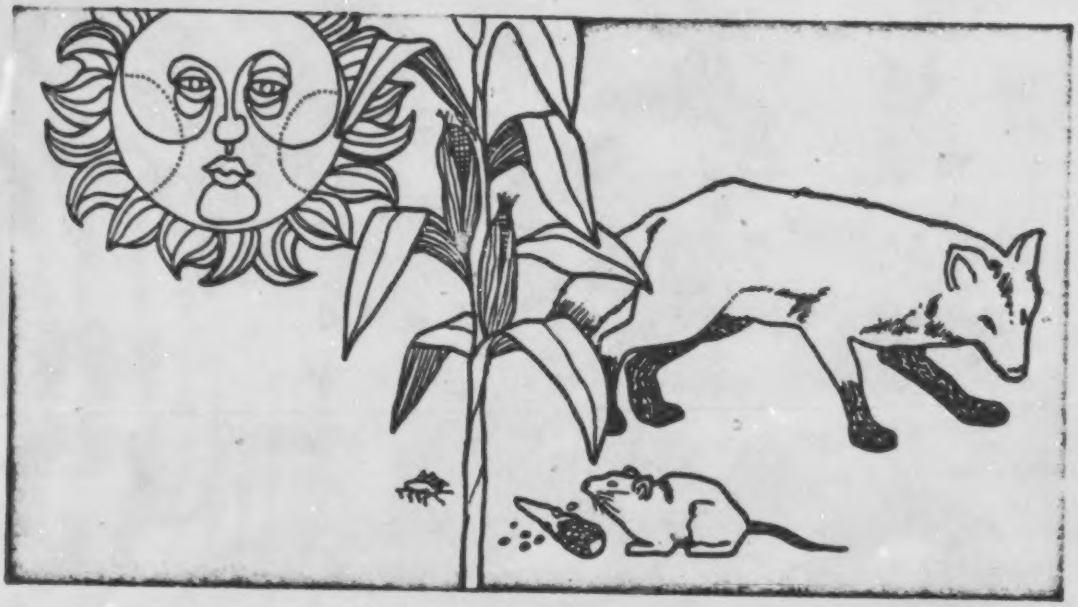


Figure 2-7

☐**2-14.** In your Record Book, list the things that each of the living organisms shown in Figure 2-7 must take from its surroundings in order to survive.

Corn Plant	Rat	"Bug"	Fox

☐**2-15.** What output products would you predict for each living organism in Figure 2-7?

Corn Plant	Rat	"Bug"	Fox

Each of the organisms in Figure 2-7 needs to take in air, water, and certain solid substances from its surroundings. The solids taken in by the plant are usually dissolved in the water that comes in through the plant roots. Each of the organisms also produces certain waste products, which are output to the surroundings. These wastes result from the chemical changes occurring within the organisms. The combined activities of living organisms change the environment. These changes in the environment have their effect on the living things. This constant interaction of environment and the life it contains is illustrated in Figure 2-8.

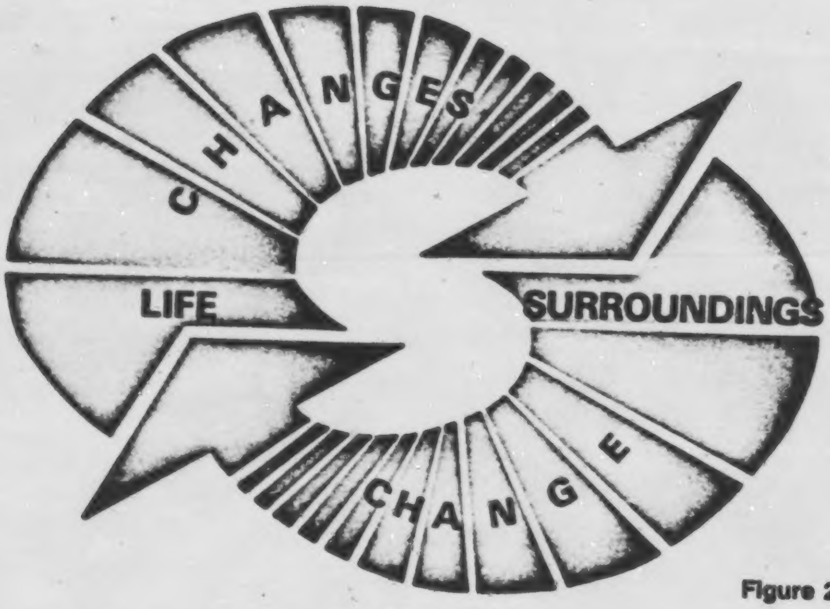
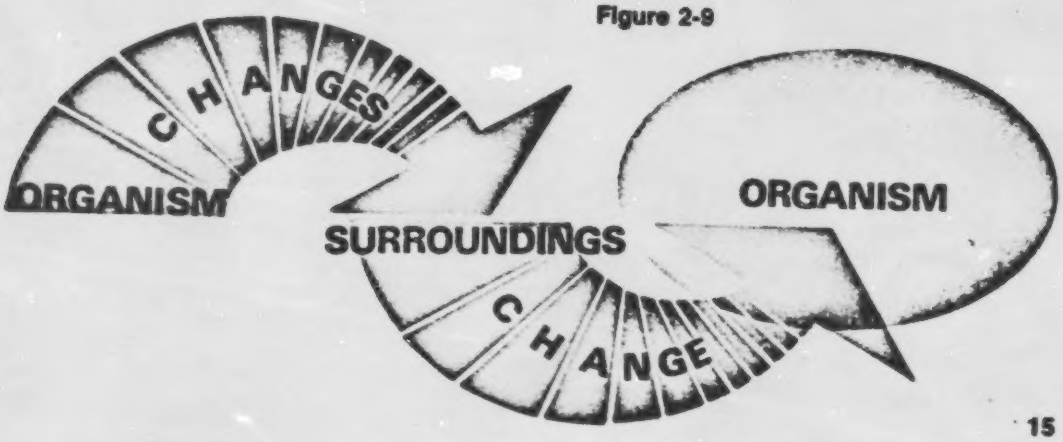

CHANGES
LIFE
SURROUNDINGS
CHANGE

Figure 2-8

Living organisms affect each other, too. These effects may be indirect, or they may be direct. If one animal eats another, he is certainly having a direct effect on that animal. Indirect effects between living things are usually not so obvious. They generally involve input-output exchanges between some organism and its surroundings. The resulting changes in the surroundings then affect some other organism. Thus the influence of one organism on the other is indirect. See Figure 2-9.

Figure 2-9


CHANGES
ORGANISM
SURROUNDINGS
ORGANISM
CHANGE

☐**2-16.** What direct effects do you suspect the living things in Figure 2-7 have on each other?

☐**2-17.** What indirect effects do you suspect the organisms in Figure 2-7 have on each other?

Look at a specific example of a very important indirect influence of one group of organisms on another. In addition to supplying a source of solid food for some animals, green plants also increase the amount of oxygen in the air. When light shines on them, a series of complicated chemical changes occurs within green plants. This series of chemical changes is called *photosynthesis.* During photosynthesis, air and water are taken in by the plant. Some oxygen and a lot of carbon dioxide are removed from the air and used by the plant to supply its own needs. While photosynthesis is occurring, the plant produces more oxygen than it uses. This excess is released to the atmosphere.

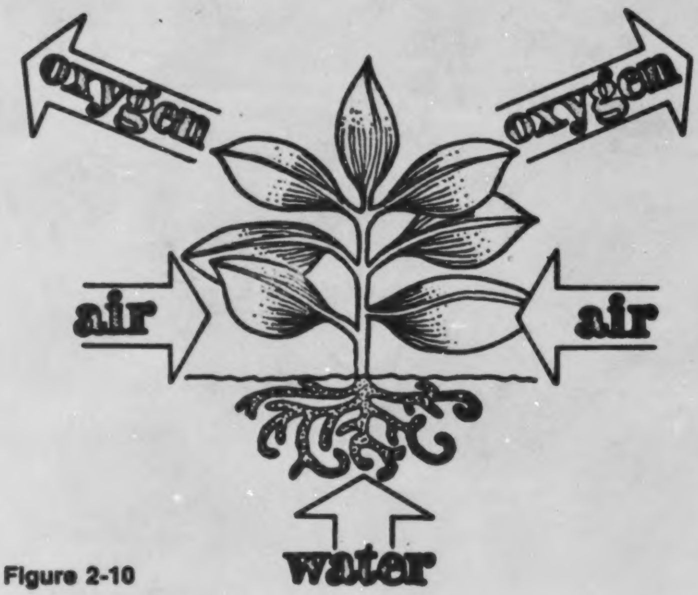


Figure 2-10

☐**2-18.** During photosynthesis, the output of green plants increases the amount of what gas in the surroundings?

☐**2-19.** During photosynthesis, the intake of green plants decreases the amount of what gas in the surrounding air?

☐**2-20.** Complete the diagram in Figure 2-11 of your Record Book by indicating the input-output gases exchanged between green plants, animals, and the atmosphere.

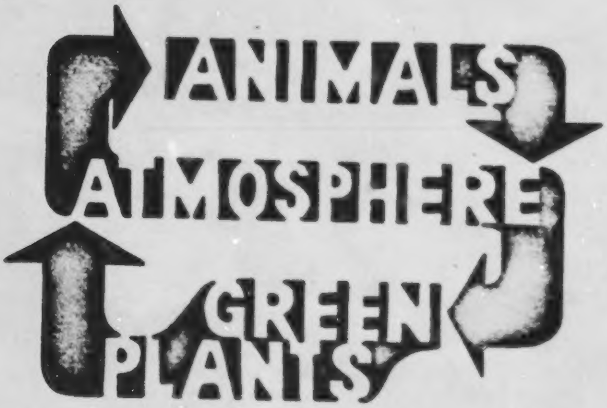


Figure 2-11

The indirect effect described in Figure 2-11 is very important. Animals take oxygen from the atmosphere and release CO_2. Plants take CO_2 and some oxygen from the atmosphere and release large amounts of oxygen. Each kind of living organism (green plants and animals) helps supply the needs of the other. The output of one becomes the input for the other, and the system is in balance.

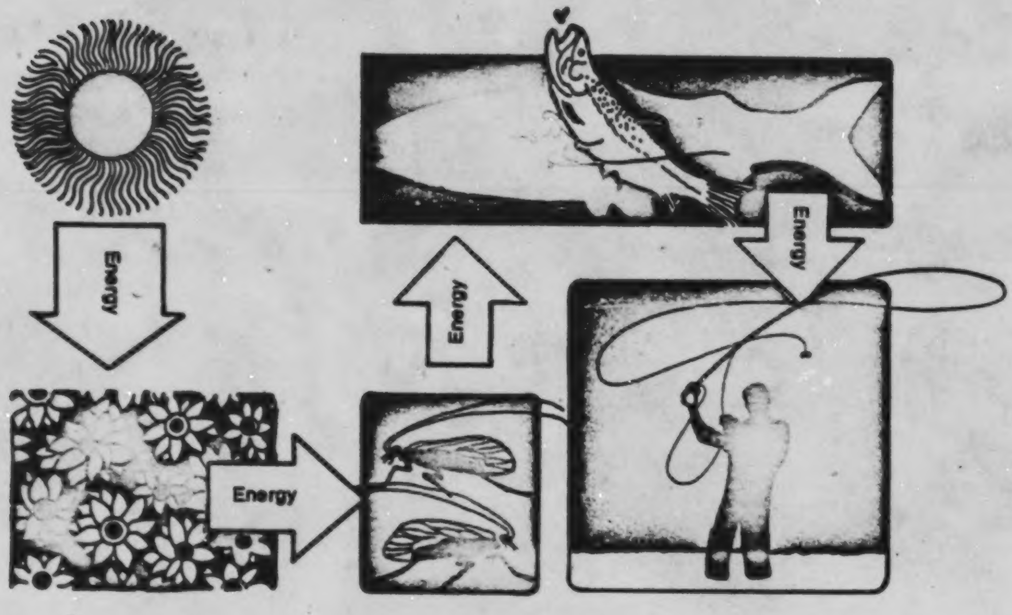
☐**2-21.** What would happen to the surrounding atmosphere if all green plants were suddenly destroyed?

☐**2-22.** What would happen to the surrounding atmosphere if the number of animals needing oxygen were suddenly increased greatly?

As mentioned earlier, all living things must have energy to change the raw materials they consume into chemicals their bodies can use. Green plants get their energy directly from the sun. Through the process of photosynthesis, green plants are able to trap light energy from the sun. This energy is used by the plant to build the chemicals needed for growth. These chemicals store some of the energy that came originally from the sun. Because green plants are able to take energy directly from the sun and store it in the chemicals of their bodies, they are called *producers.*

Most animals cannot get the energy they need directly from the sun. They cannot carry out the process of photosynthesis. Animals must depend on getting the sun's energy in one of two indirect ways. They can eat green plants, or they can eat other animals that eat plants. Animals are called *consumers.*

Figure 2-12



☐**2-23.** The output of plants (oxygen) and the plants themselves benefit animals. What output of animals can be of benefit to green plants?

In addition to the CO_2 they release, the waste products of the animals and their bodies when they die are beneficial to plants. But if plants are to be able to use these waste products, another kind of organism must be involved. Microscopic organisms—mostly bacteria—in the soil and in the air can produce chemical changes in the waste materials and dead bodies of animals and plants. The products of these chemical changes can then be used by living plants. The microscopic organisms, as a group, are known as *decomposers.*

☐**2-24.** In your Record Book, sketch an input-output diagram in which you illustrate how the components in the system shown in Figure 2-13 influence each other. Show all the input-output relationships you can think of. Remember, these relationships may be direct, or they may be indirect.

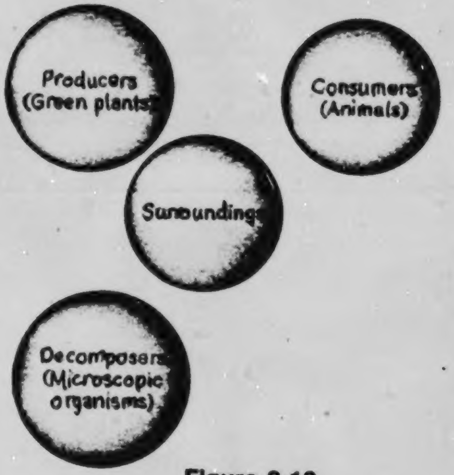


Figure 2-13

Each living thing affects its environment and thereby other living things. If input-output effects are in balance, the environment is safe from damaging change. But if for some reason the input-output balance is upset, drastic results may occur.

☐**2-25.** What do you predict would happen if all plant consumers in an area were suddenly killed?

☐**2-26.** What would be likely to be the result of poisoning all the decomposers in a given area?

☐**2-27.** What would be the effect, in a given area, of a sudden increase in animals that consumed other animals?

Man has affected the relationships between many of the organisms in his environment. Sometimes he has done this accidentally. At other times he has purposely tried to change natural balances. If you would like to learn more about one such attempt, turn to **Excursion 2-2,** "Bounty Hunters."

◀EXCURSION

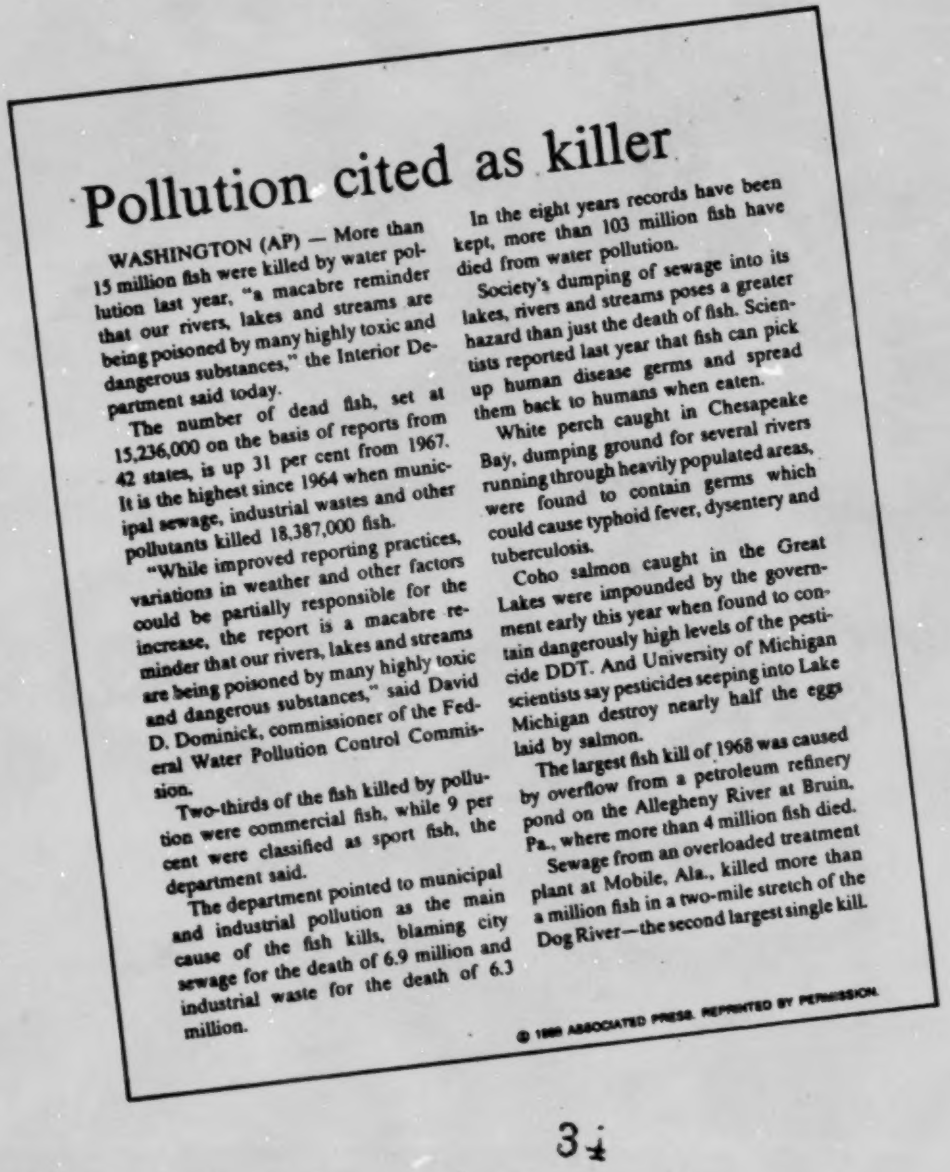
At the beginning of this chapter, you saw how even small changes in the environment are important. They add up to large effects. The effects of your own personal activities, though they may seem small, are really quite important. The living and nonliving world depends on an input-output balance. Man's activities can either keep or destroy that balance. Keeping things in balance is a tough job. Your activities are part of man's total effect on the environment. Therefore you must accept part of the responsibility for keeping things in balance. The following chapters will help you see what kinds of problems you and your surroundings face.

Before going on, do Self-Evaluation 2 in your Record Book.

33

Water, Water Everywhere . . . But . . .

Chapter 3



Pollution cited as killer

WASHINGTON (AP) — More than 15 million fish were killed by water pollution last year, "a macabre reminder that our rivers, lakes and streams are being poisoned by many highly toxic and dangerous substances," the Interior Department said today.

The number of dead fish, set at 15,236,000 on the basis of reports from 42 states, is up 31 per cent from 1967. It is the highest since 1964 when municipal sewage, industrial wastes and other pollutants killed 18,387,000 fish.

"While improved reporting practices, variations in weather and other factors could be partially responsible for the increase, the report is a macabre reminder that our rivers, lakes and streams are being poisoned by many highly toxic and dangerous substances," said David D. Dominick, commissioner of the Federal Water Pollution Control Commission.

Two-thirds of the fish killed by pollution were commercial fish, while 9 per cent were classified as sport fish, the department said.

The department pointed to municipal and industrial pollution as the main cause of the fish kills, blaming city sewage for the death of 6.9 million and industrial waste for the death of 6.3 million.

In the eight years records have been kept, more than 103 million fish have died from water pollution.

Society's dumping of sewage into its lakes, rivers and streams poses a greater hazard than just the death of fish. Scientists reported last year that fish can pick up human disease germs and spread them back to humans when eaten.

White perch caught in Chesapeake Bay, dumping ground for several rivers running through heavily populated areas, were found to contain germs which could cause typhoid fever, dysentery and tuberculosis.

Coho salmon caught in the Great Lakes were impounded by the government early this year when found to contain dangerously high levels of the pesticide DDT. And University of Michigan scientists say pesticides seeping into Lake Michigan destroy nearly half the eggs laid by salmon.

The largest fish kill of 1968 was caused by overflow from a petroleum refinery pond on the Allegheny River at Bruin, Pa., where more than 4 million fish died.

Sewage from an overloaded treatment plant at Mobile, Ala., killed more than a million fish in a two-mile stretch of the Dog River—the second largest single kill.

© 1969 ASSOCIATED PRESS. REPRINTED BY PERMISSION.

In this chapter and the next two, you will investigate some important changes that are taking place in our lakes, streams, and rivers. Your job is to find out how the input-output systems in these waters respond to these changes. A good place to begin is by investigating the effect of man's output on some of the smallest living things—the microorganisms.

Almost all natural surface waters of the earth contain bacteria and other microorganisms. As you know, decomposers, mostly microorganisms, use the dead bodies and waste output of other creatures as their source of food and energy. As they do this, they take in oxygen from the surroundings and release CO_2.

☐**3-1.** Where do the microorganisms living in surface waters get the oxygen they need to live?

BIOCHEMICAL OXYGEN DEMAND

Most living things must have some oxygen to live. Oxygen is an important reactant in many of the chemical changes that occur in the bodies of living things. Therefore, it is essential that this gas be available in the water environment. The need for oxygen by living things is known as the *biochemical oxygen demand* (B.O.D.).

☐**3-2.** Which organisms that live in the water might be suppliers of oxygen?

In the series of activities that follow, you will investigate how the B.O.D. of microorganisms is affected by changes in the water surrounding them. Then you may see that the B.O.D., in turn, affects the water.

As mentioned earlier, decay organisms feed on waste material; therefore, sewage is a source of their food supply.

☐**3-3.** What effect do you predict increasing the food supply of an organism will have on the size of the population of that kind of organism?

☐**3-4.** Suppose the amount of sewage being added to a river were increased. What effect do you predict this would have on the B.O.D. of decay microorganisms?

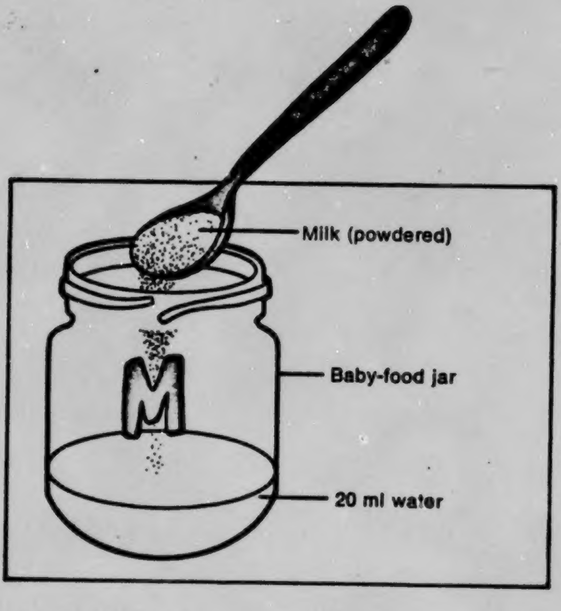
You could check your answer to question 3-4 by investigating the effects of sewage on decay microorganisms. However, rather than work with such an unpleasant material, you can investigate a similar system that is more sanitary.

If you had Volume 2 of ISCS, you are already acquainted with yeast, a microorganism that uses sugar as a source of food. Yeast will represent the decay organisms in the river water. Powdered milk contains sugar and will represent the sewage that is dumped into the river.

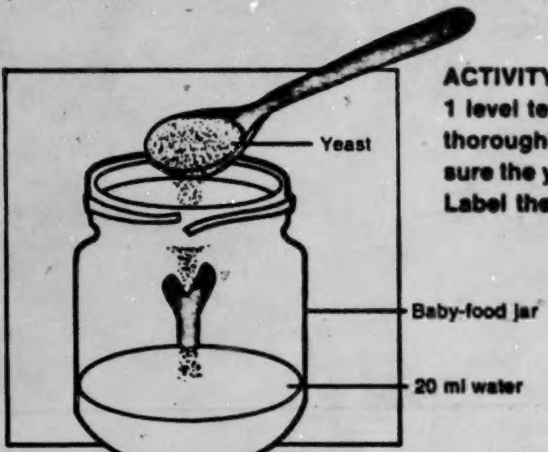
YEAST
MILK
MILK
MILK
MILK
MILK
MILK

You will investigate how increasing the amount of sewage (milk) affects the oxygen demand of the decay organisms (yeast). To do this, you will need about 25 minutes and the following materials:

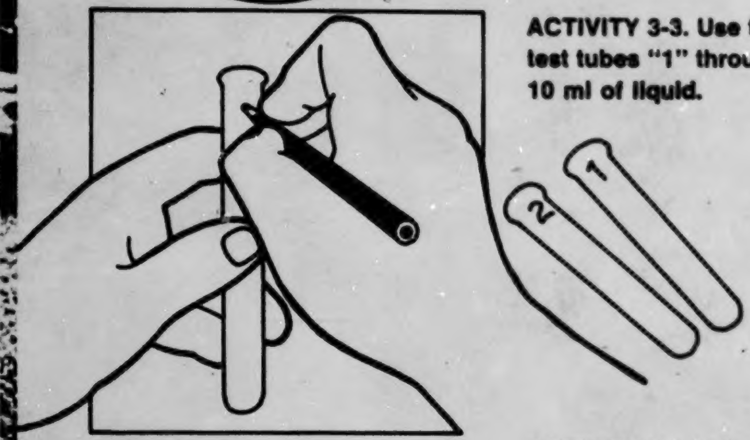
1 plastic spoon
2 baby-food jars
1 level teaspoon of powdered milk
1 level teaspoon of dry yeast
1 dropper bottle of methylene blue solution
2 5-ml air pistons
1 stirring rod
3 test tubes (all the same size with capacity of at least 10 ml)
1 test-tube rack
1 wax marking pencil
1 watch or clock



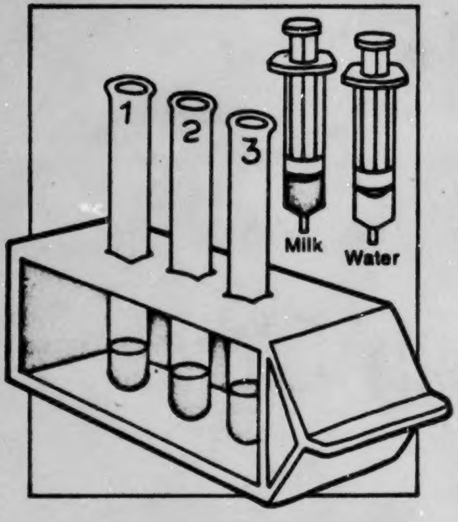
ACTIVITY 3-1. Prepare a sample of milk by slowly stirring 1 level teaspoon of powdered milk into 20 ml of tap water in a baby-food jar. Mark the jar with an "M."



ACTIVITY 3-2. Prepare a sample of yeast by slowly stirring 1 level teaspoon of dry yeast into 20 ml of water and mixing thoroughly. After a minute or so, stir the mixture again. Be sure the yeast is well mixed and has not settled to the bottom. Label the jar "Y."



ACTIVITY 3-3. Use the marking pencil to number three clean test tubes "1" through "3." These tubes should hold at least 10 ml of liquid.



ACTIVITY 3-4. Using one 5-ml air piston for water and another 5-ml air piston for milk, add to the three test tubes the exact amounts called for in Table 3-1. Stir each mixture thoroughly.

☐**3-5.** What is the total volume of liquid in each tube?

☐**3-6.** Which tube has the highest concentration of milk?

☐**3-7.** Which tube has the lowest concentration of milk?

The methylene blue solution you will use next is called an indicator. Its blue color indicates the presence of dissolved oxygen gas. If methylene blue is added to a liquid containing dissolved oxygen, and if the oxygen is then used up, the blue indicator will become colorless. This is illustrated in Figure 3-1. Notice that both tubes show a colored layer at the surface of the liquid.

Test Tube	Milk (ml)	Water (ml)	Concentration of Milk (%)
1	0.5	5.5	8.3%
2	3.0	3.0	50 %
3	6.0	0	100 %

Table 3-1

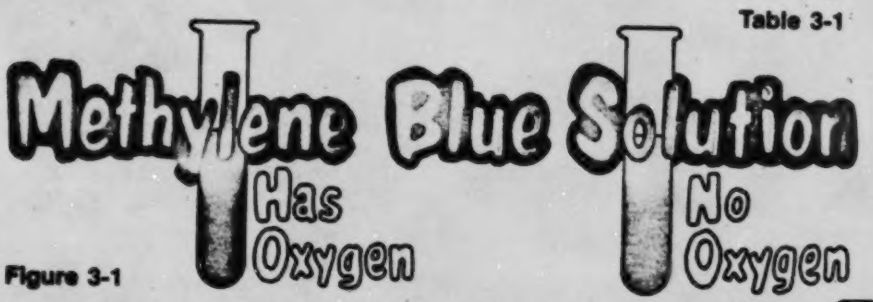
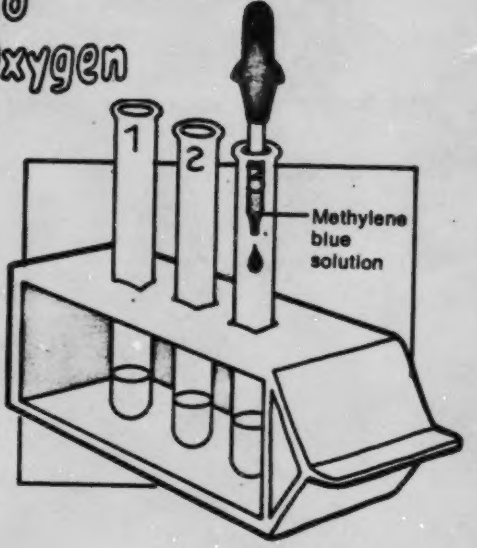


Figure 3-1

☐**3-8.** Why would methylene blue indicate that oxygen is present at the surface of the liquid in Figure 3-1?

ACTIVITY 3-5. Add 20 drops of methylene blue solution to each tube. Mix thoroughly.



☐**3-9.** Does each of the three milk-methylene blue mixtures contain dissolved oxygen?

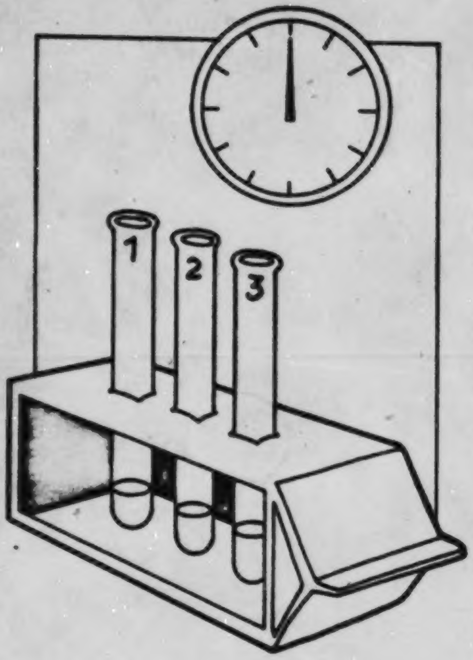
You are about ready to mix the milk (sewage) and the yeast (decay) microorganisms to see what happens to the B.O.D. The milk mixtures in tubes 1, 2, and 3 represent different concentrations of sewage. Look again at your answer to question 3-4.

☐**3-10.** What do you predict will happen to the blue color in the three tubes if the yeast uses up all the oxygen?

☐**3-11.** In which tube would you expect a change to occur first?

You are now ready to mix these with the microorganisms. Instead of adding the sewage to the yeast, it is easier to add the yeast to the sewage.

You will need about 20 minutes to complete all your observations.



ACTIVITY 3-6. Add 2 ml of yeast solution to the first test tube, mixing thoroughly. Record in Table 3-2 the exact time the mixing starts. Once the timing has begun, don't disturb the tube. Jostling it will introduce air into the liquid.

While you are waiting, you should repeat this procedure for the other two tubes. Be sure to record the starting times in Table 3-2.

It may take several minutes for any change to occur. Observe carefully. Record the "Time of change" for each tube when you see that the blue color has disappeared from all but the surface area. Note that because of the addition of the milk-yeast mixture, the solution will not be colorless. Take a look at the sample tube your teacher has prepared. This will help you know when the liquids have lost all their blue color.

Table 3-2

	Time for Change to Occur		
Test Tube	Time of Mixing	Time of Change	Total Time for Change
1			
2			
3			

☐**3-12.** Was your prediction in question 3-10 correct?

☐**3-13.** Did you predict correctly for question 3-11?

☐**3-14.** How do you account for the differences in time required for the color changes to occur?

The more food supplied to the microorganisms, the faster the dissolved oxygen supply is used up. This is what you have observed. How do these observations apply to the decay microorganisms in surface water?

☐**3-15.** What effects would dumping large quantities of sewage into a river, stream, or lake be likely to have on the amount of oxygen dissolved in the water?

When the food supply of a population of organisms is increased, the population usually increases. If the population of an organism increases, the biochemical oxygen demand of that population must also increase. These relationships are illustrated in Figure 3-2.

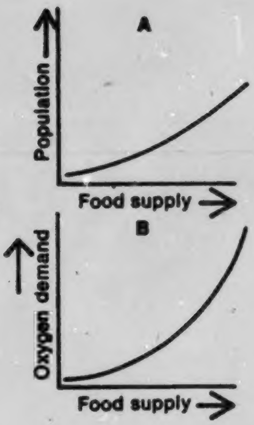


Figure 3-2

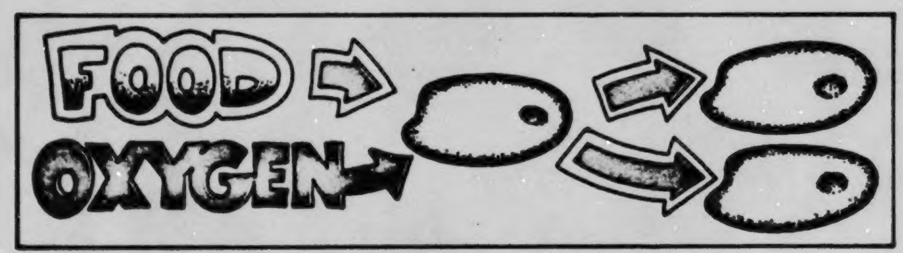
☐**3-16.** What do you predict happens to the population of decay microorganisms when sewage is dumped into their environment?

☐**3-17.** Predict the effect an increase in decay microorganisms would have upon their biochemical oxygen demand.

☐**3-18.** What effect would increasing the B.O.D. of one kind of organism population have on the populations of other oxygen-using organisms in the same environment?

If sewage that is dumped into a lake or river is to be decomposed (reduced to smaller particles), decay organisms must do it. In response to the input of sewage, the organisms increase in number. How fast does the microorganism population increase?

Microorganisms reproduce by dividing. Each one divides into two exactly like the first.



If sufficient food and oxygen are available, some microorganisms can divide as often as every 20 minutes.

☐**3-19.** Suppose you had one such organism. After 40 minutes, how many would you have? After 20 minutes more, how many would you have?

☐**3-20.** Suppose you started with one microorganism that divides every 20 minutes. Suppose, also, each new organism that is produced lives and is able to continue dividing. How many of the organisms would there be in 2 hours?

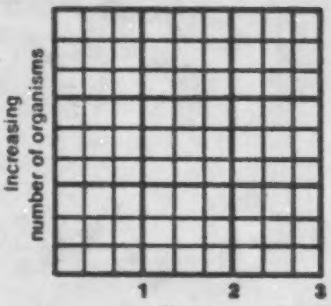


Figure 3-3

☐**3-21.** In Figure 3-3 of your Record Book, sketch an approximate graph representing the population increase of the microorganisms during a 3-hour period.

☐**3-22.** How should the increase in an oxygen-using population of microorganisms affect the amount of oxygen present in an environment?

From time to time in this unit, you will be asked to do Problem Breaks. These are problems for you to solve, without much help from your book or your teacher. The problems will usually help you to understand what you are studying in the chapter. But that's not their major purpose. They are designed to give you practice in problem solving, and in setting up your own experiments. You should try every Problem Break—even the tough ones. And in most cases, you should have your teacher approve your plan before trying it. The first Problem Break in this unit is coming up next.

PROBLEM BREAK 3-1

Design an experiment to find out if increasing the amount of yeast increases the amount of oxygen consumed. Let your teacher review your plan before you begin the investigation. Record your plan, results, and conclusions in your Record Book.

Now let's look at what you have found in this chapter. A large input of sewage into surface water upsets the input-output balance. There is a rapid increase in the population of microorganisms (Figure 3-3). As a result of this increase, a great demand is placed on the available oxygen.

This makes it tough on other living things that need oxygen. Even the decay organisms begin to suffer as they use up their oxygen supply. If they can, organisms will move to a more favorable place. Of course, some organisms, such as rooted plants and attached animals, are not able to move.

Decay microorganisms chemically decompose sewage and other wastes. These organisms are very important. They help keep the environment clean. And they are the primary means whereby the chemical elements necessary for life can be released from dead bodies and other wastes to the soil and water. Figure 3-4 illustrates the role of decay organisms.

As long as there isn't an overabundance of waste materials

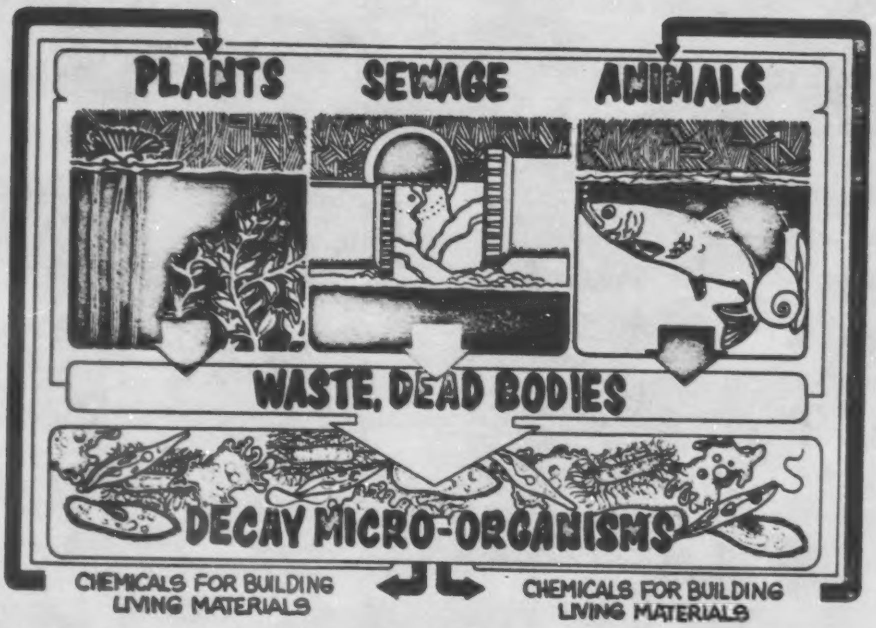

PLANTS
SEWAGE
ANIMALS
WASTE, DEAD BODIES
DECAY MICRO-ORGANISMS
CHEMICALS FOR BUILDING LIVING MATERIALS
CHEMICALS FOR BUILDING LIVING MATERIALS

Figure 3-4

in the water, the microorganisms can decompose most of the chemical compounds that tie up the elements. However, when an abundance of waste material is added to their environment, the microorganisms reproduce rapidly. With the increase in the population, the rate of decomposition increases. This uses up the oxygen in the water more rapidly. This effect of sewage and other wastes on the biochemical oxygen demand is very important. It accounts for the "oxygen death" of many rivers and lakes.

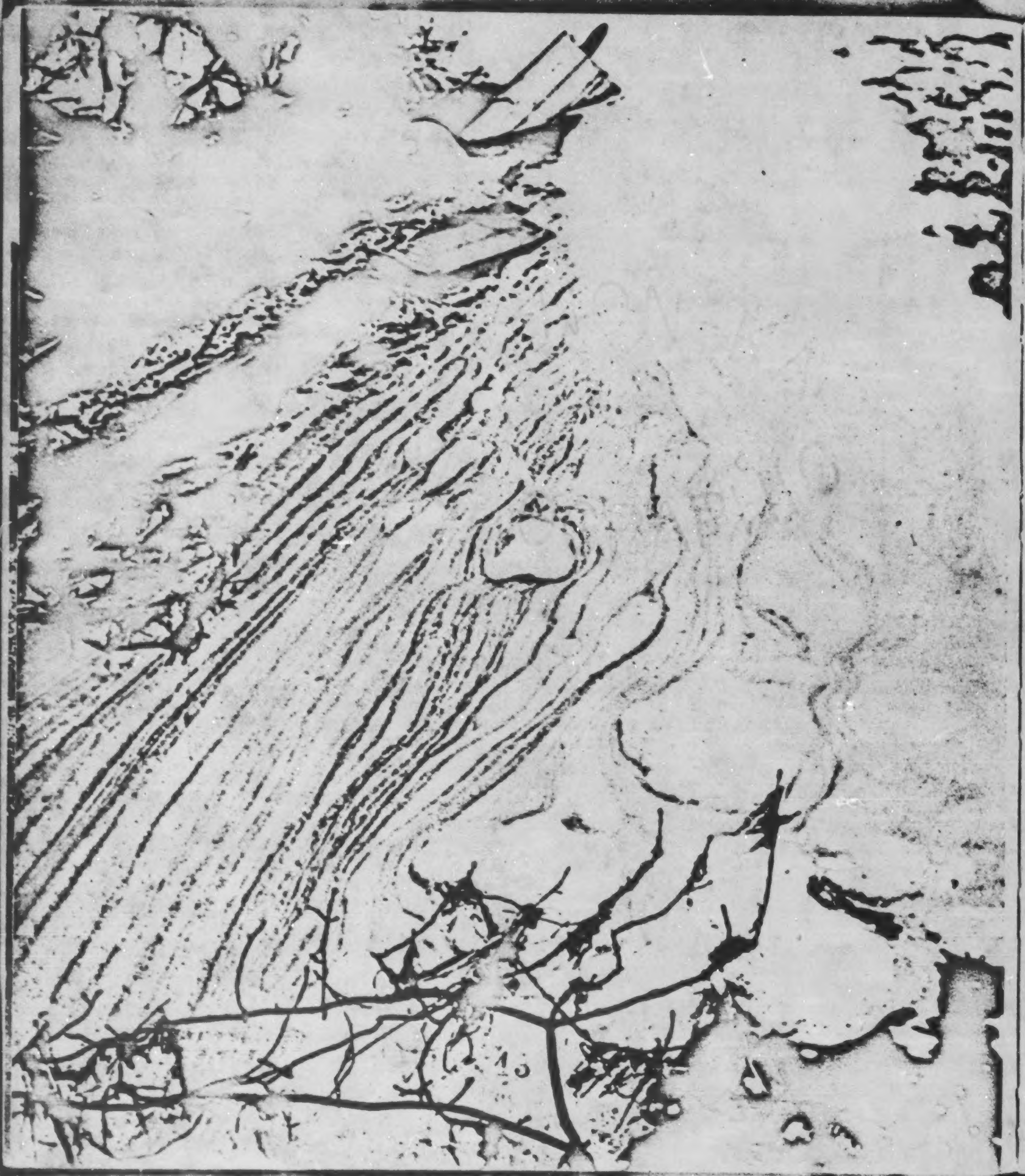
PROBLEM BREAK 3-2

The pollution of our environment is receiving worldwide attention. You might want to collect newspaper and magazine articles and pictures related to pollution problems. These could be used in preparing a display for your science room.

In this chapter, you've investigated one kind of water pollution. In the next two chapters, you will investigate additional examples. Before going on, however, you should be sure you are familiar with the "water cycle." To review this important idea, turn to **Excursion 3-1**, "A Drink of the Nile."

◀EXCURSION

Before going on, do Self-Evaluation 3 in your Record Book.


15

The Undesirables

Chapter 4

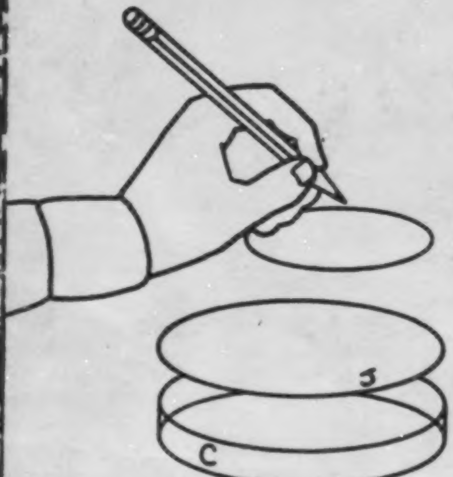
You are very fortunate if you are the first human to use water during its most recent cycle on the earth. Most of us drink water that has already been used by one or more persons upstream. Of course, the used water is usually safe because it has passed through purification plants. However, as the earth's population increases, more and more water is used again and again during its journey to the sea. And it becomes exceedingly difficult to remove undesirable chemicals from water. In this chapter, you will investigate the effects of two substances that can be considered as undesirable—cleaning agents and pesticides. Normally useful to man, these substances are most undesirable in surface water.

Up until the 1930's, soaps were the principal cleaning agents for home and industry. Then detergents were developed. They rapidly became very popular because they had better sudsing properties than soap. Detergents were faster acting and longer lasting. And detergents did not leave the common "bathtub ring" so characteristic of soaps. Unfortunately, the good cleaning features of detergents turned out to be their poorest characteristics as far as surface water was concerned. As detergents from millions of kitchen and bathroom sinks and from thousands of factories and businesses were dumped into surface waters, suds began to collect in rivers, streams, and lakes. Because the detergents are so long-lasting, sudsy water even flowed from taps in some homes! Surely such contaminated water must affect living organisms. Perhaps you would like to see for yourself.

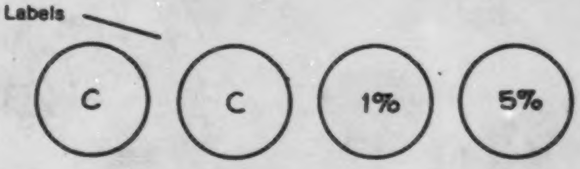
What do you predict will happen to seeds a farmer sows if the water he uses to "get them going" (germinate them) contains detergent wastes? Will the detergent affect the number of seedlings that germinate? Will it affect the seedling's growth?

In the following activities, you will try to answer these questions. You will investigate the effect of detergent on the germination and growth of seedlings. You and your partner will need about 15 minutes to set up the investigation. Completion of the experiment will take several days. Rather than wait for things to happen, you will be starting other activities as soon as you get this first one going. Get the following materials:

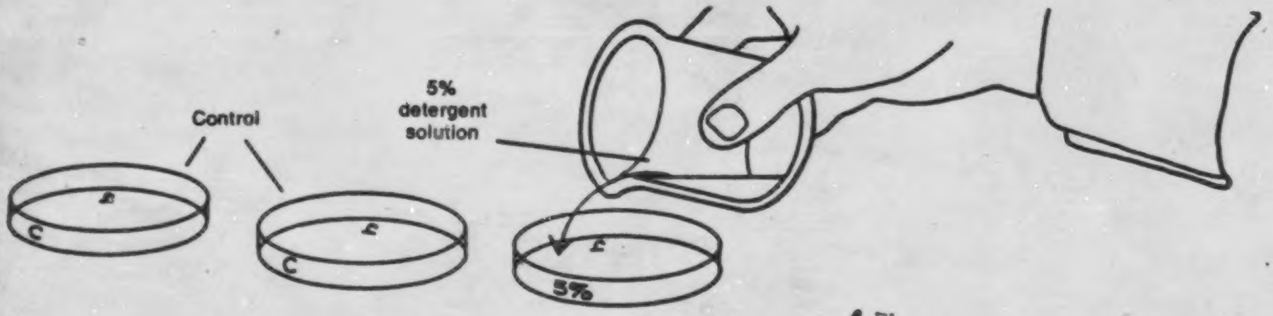
1 wax marking pencil
4 plastic petri dishes with lids
4 pieces of paper toweling cut to fit the bottom of the petri dishes
40 (approx.) radish seeds
10 ml of 1% detergent solution (already prepared)
10 ml of 5% detergent solution (already prepared)
Tape
Tap water



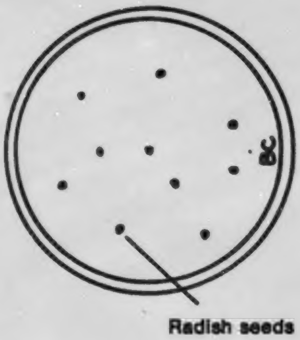
ACTIVITY 4-1. Be sure the petri dishes are clean. Then label them as shown, using a wax marking pencil. Using an ordinary pencil, put your initials on each piece of toweling and place one piece of towel in each dish.



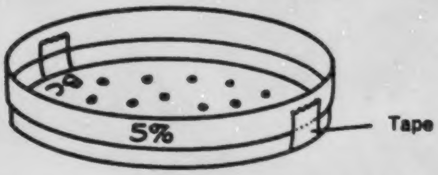
ACTIVITY 4-2. Pour 10 ml of tap water into each of the "control" dishes. Pour 10 ml of the 5% detergent solution into the dish marked "5%." (You are using two control dishes here because you will need them both later.) Put 10 ml of the 1% solution in the dish marked "1%."



ACTIVITY 4-3. Place ten radish seeds in each dish. Spread them out as shown.



ACTIVITY 4-4. Cover each dish with a taped-on lid and put the dishes in a place provided by your teacher. Begin your observations of the seeds during your next class period, as indicated in Activity 4-5.



If you have some time remaining in this class period, you may begin the following problem break.

PROBLEM BREAK 4-1

Do chemical changes occur in a seed as it germinates? For example, does it exchange gases with its environment? Here's how to find out. You will need the following materials:

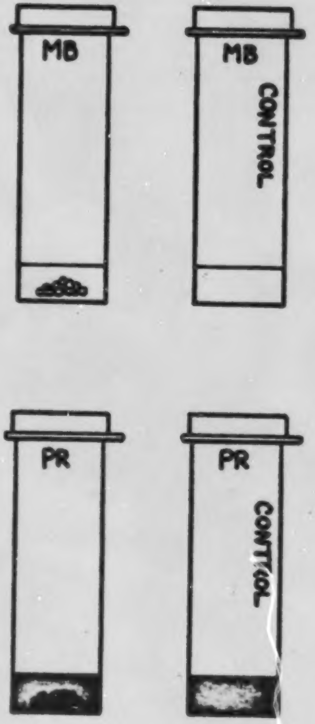
2 doz. radish seeds	8 ml tap water
4 plastic vials with lids	2 ml phenol red
2 ml methylene blue	

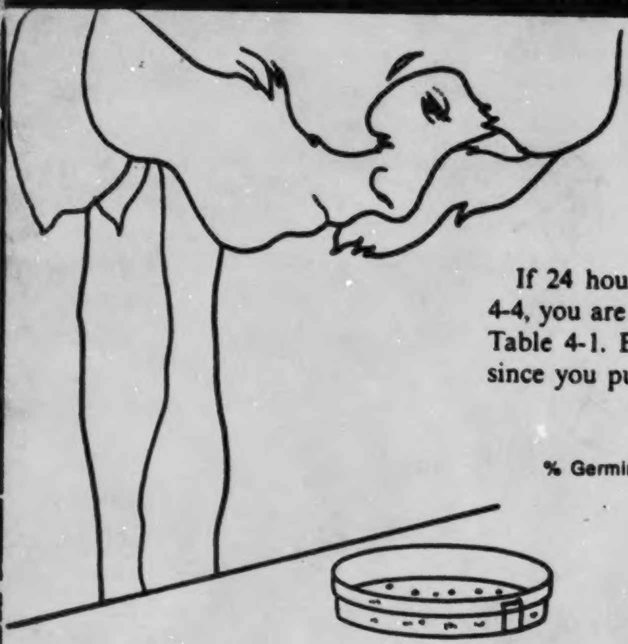
Put about a dozen radish seeds into a plastic vial. Add 2 ml of tap water and 1 ml of methylene blue indicator. Prepare a control by putting 2 ml of water and 1 ml of methylene blue indicator into another vial. Leave the seeds out of the second vial.

Repeat the same procedure with two more vials, but use phenol red indicator instead of methylene blue. (A change in color of phenol red to yellow can be used to indicate the presence of CO_2 gas.)

Note and record in your Record Book the initial appearance of each of the four vials. Set them aside in a designated place until tomorrow. Then record your observations again and provide a written explanation of the results. Your discussion should include answers to the following questions:

1. Do chemical changes occur in a seed as it germinates?
2. Do germinating radish seeds, absorb, or release, CO_2?
3. Do germinating radish seeds absorb, or release, oxygen?





If 24 hours or more have passed since you did Activity 4-4, you are ready to go ahead with Activity 4-5 and to start Table 4-1. Be sure to record how many hours it has been since you put the seeds in the vials.

$$\text{\% Germinated} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds in dish}}$$

ACTIVITY 4-5. Look at the dishes with the radish seeds. Do not remove the covers. Record the percent germinated in the space provided in Table 4-1 of your Record Book. Five out of ten would be 50% germinated. (A seed has germinated if you can see part of a root poking out of it). Don't throw the seedlings away! You'll observe them again and you may want to use them for Excursion 4-1.

Table 4-1

Day Observed	Hours Elapsed	DISH C (Control): % Germinated	1% Detergent Solution: % Germinated	5% Detergent Solution: % Germinated
1				
2				
3				

☐4-1. In Table 4-2 of your Record Book, describe the seedlings in each dish. Your description should answer questions such as these:

1. Are the roots, stems, and leaves visible or not?
2. Have the leaves unfolded?
3. Are the leaves yellowish, whitish, or green?
4. Are root hairs (tiny fuzzy growths) visible?

Day Observed	Description of Seedlings in Control Dish	Description of Seedlings in 1% Detergent Solution	Description of Seedlings in 5% Detergent Solution
1			
2			
3			

Table 4-2

You should keep the covers on the seed dishes so that the water won't evaporate. Observe them again each day for the next two class periods. Record the data that is called for in Tables 4-1 and 4-2.

In the meantime, check the results to Problem Break 4-1. Then go ahead to Problem Breaks 4-2 and 4-3 while you are waiting for the completion of the seed-germination time.

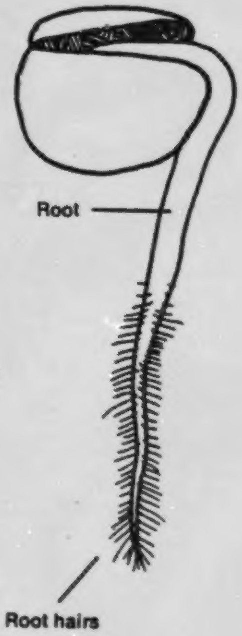
PROBLEM BREAK 4-2

You may have noticed the tiny root hairs on the roots of the radish seedlings. Find out what role these root hairs play in the life of a plant. Your school library probably has several books and encyclopedias that can tell you more about plant growth. Record your findings in your Record Book.

PROBLEM BREAK 4-3

Assume you live in a small town and you are the chairman of the city planning commission. A large detergent industry is interested in locating a new plant there. The plant would provide employment for 500 to 600 people. This would add over $1,000,000 per year to the money spent in city stores and for local services. In addition, it would mean tax money for the community. If this company locates in your town, other industries may, in turn, decide to do so. This could be the beginning of major growth for your area.

The company's president admits that the new plant may cause some detergent pollution of a nearby river. He says, however, that at this time his company could not spend more than a few thousand dollars per year in trying to eliminate this pollution.



As chairman of the city planners, you have to vote for or against allowing the industry to locate in your town. Think about the advantages and the disadvantages to your city. What additional information would help you decide how to vote? What will your vote be and why? Discuss your ideas with some of your classmates.

You should now have completed your investigation of the effects of detergent solution of the germination and growth of seeds. Be sure you have completed Tables 4-1 and 4-2 before going ahead.

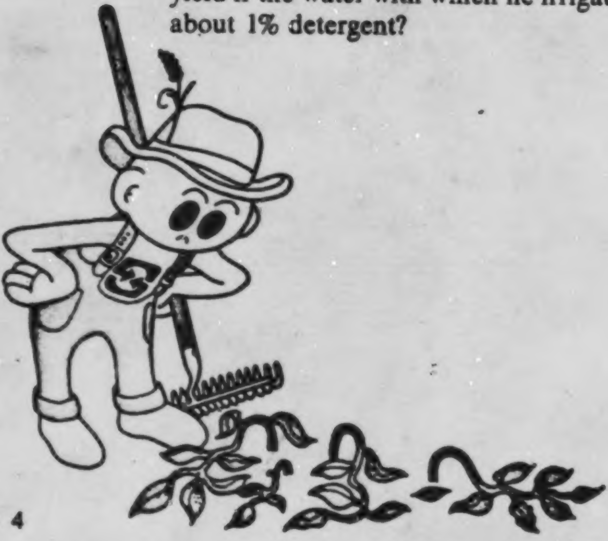
☐**4-2.** Did either the 1% or the 5% detergent solution seem to inhibit (slow down) the germination of the radish seeds?

☐**4-3.** Was the germination of the seeds affected by the detergent? If so, in what way?

☐**4-4.** How many of the seeds in the 5% detergent solution germinated? How many in the 1%? How many in the control?

☐**4-5.** Describe the differences in appearance and size (if there are any) between the control seedlings and those in the 1% and 5% detergent solutions by the time of the third observation.

☐**4-6.** What would you expect to happen to a farmer's crop yield if the water with which he irrigated his crops contained about 1% detergent?



As a result of your investigation, you may have concluded that the farmer could expect a scantier crop of whatever he had planted. You might also have concluded that the plants that lived would be likely to be weak and undersized.

Perhaps you would like to learn more about how detergents could affect crop growth. If so, turn to **Excursion 4-1**. This is an excursion you can do at home if you wish. You will need the control seedlings from Activity 4-5. You may discard the other seeds. To avoid damaging the seedlings, be sure to read the first two activity frames of this excursion now.

◀ EXCURSION

The effects on living things of chemical wastes from detergents and from industrial and agricultural processes are very important. These effects may be quite harmful, particularly to organisms living in surface waters. These bad effects result mainly from one of two characteristics of chemicals:

1. Some chemicals can be decomposed and used as a source of food for one or more living organisms.
2. Some chemicals are not easily decomposed and accumulate over a period of time.

In Chapter 3 you found that certain microorganisms decompose chemical wastes. From this decomposition the decay organism gets the food it needs. In addition, essential elements are returned to the environment for reuse by other living organisms.

Chemicals that can be decomposed by organisms are said to be *biodegradable*.

BIODEGRADABLE

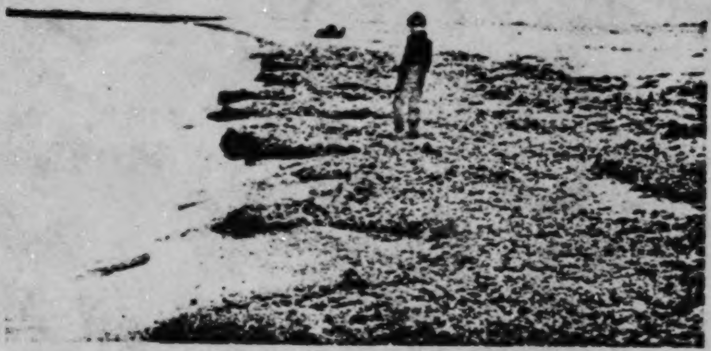
Some of the chemicals from detergent wastes are a source of food for small plant organisms called *algae* (AL jee). Phosphate compounds are good examples. The presence of these detergent wastes in streams or lakes produces rapid growth of these organisms. This increases their biochemical oxygen demand.

☐4-7. What happens to the amount of oxygen available when the B.O.D. of an organism increases rapidly?

☐4-8. How are other oxygen-using organisms affected?

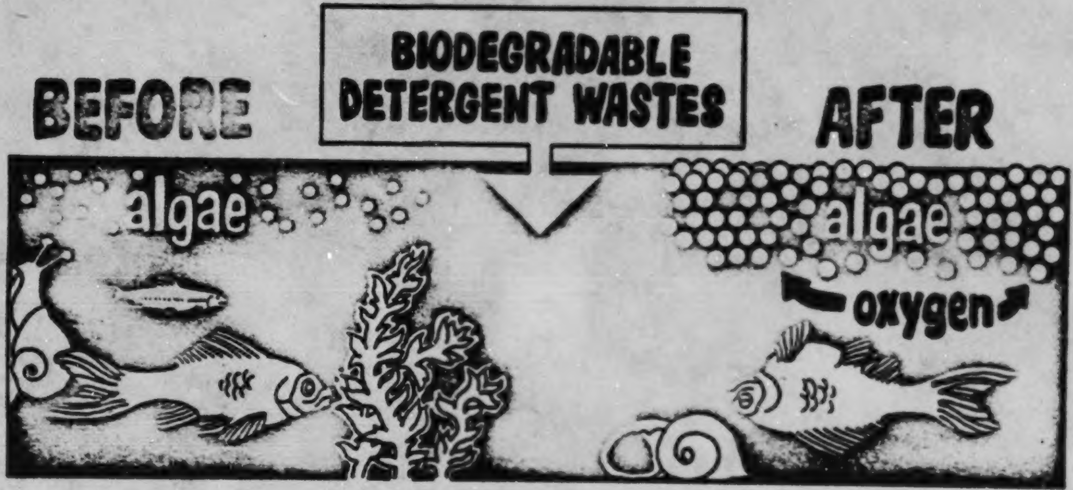
Figure 4-1 shows the result of detergent pollution of Lake Michigan.

Figure 4-1



A rapid growth of algae resulted from an abundance of detergent phosphates. The algae in the lake population increased so rapidly that dissolved oxygen in the water was used up. This loss of oxygen killed the algae as well as other living things. Algae and other dead animal and plant material were then washed up onshore.

Figure 4-2


BIODEGRADABLE DETERGENT WASTES
BEFORE
AFTER
algae
algae
oxygen

Even though the algae produced oxygen through the process of photosynthesis, they and the microscopic decomposers feeding on algae wastes used up more oxygen than the algae could resupply.

The second effect of chemical wastes in surface waters is also an important one. Some compounds are not decomposed by living organisms. They are said to be *nonbiodegradable.* Detergents can also be sources of some nonbiodegradable chemicals. However, most nonbiodegradable chemicals come from industrial and agricultural wastes. Because nonbiodegradable chemicals are not readily decomposed, these compounds accumulate in surface waters and in the mud of lakes and rivers.

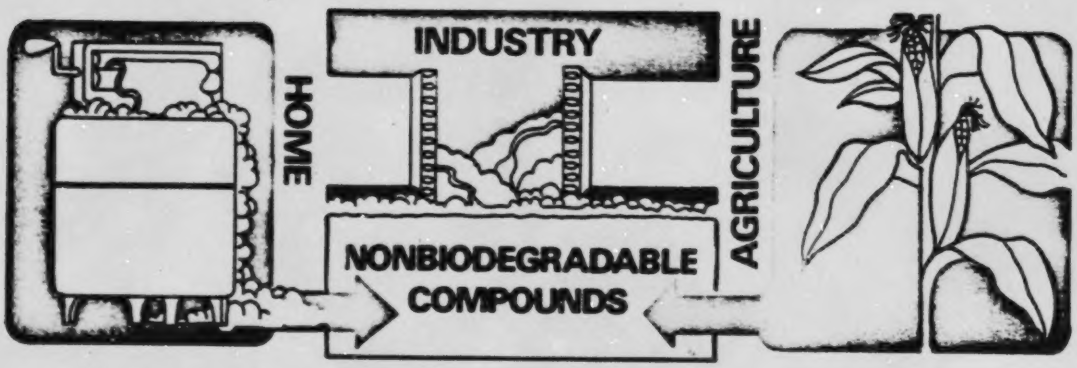


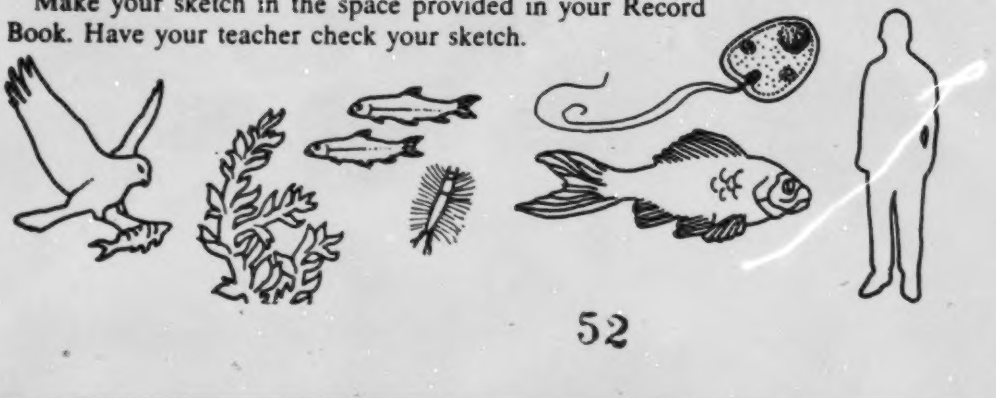
Figure 4-3

Growing plants and small animals may absorb these compounds along with the nutrients they need. These chemicals may then be passed on to large animals that feed on the plants and smaller animals.

☐**4-9.** Use the organisms shown in Figure 4-4 in a sketch that illustrates how nonbiodegradable chemical wastes may be passed from one living thing to another.

Make your sketch in the space provided in your Record Book. Have your teacher check your sketch.

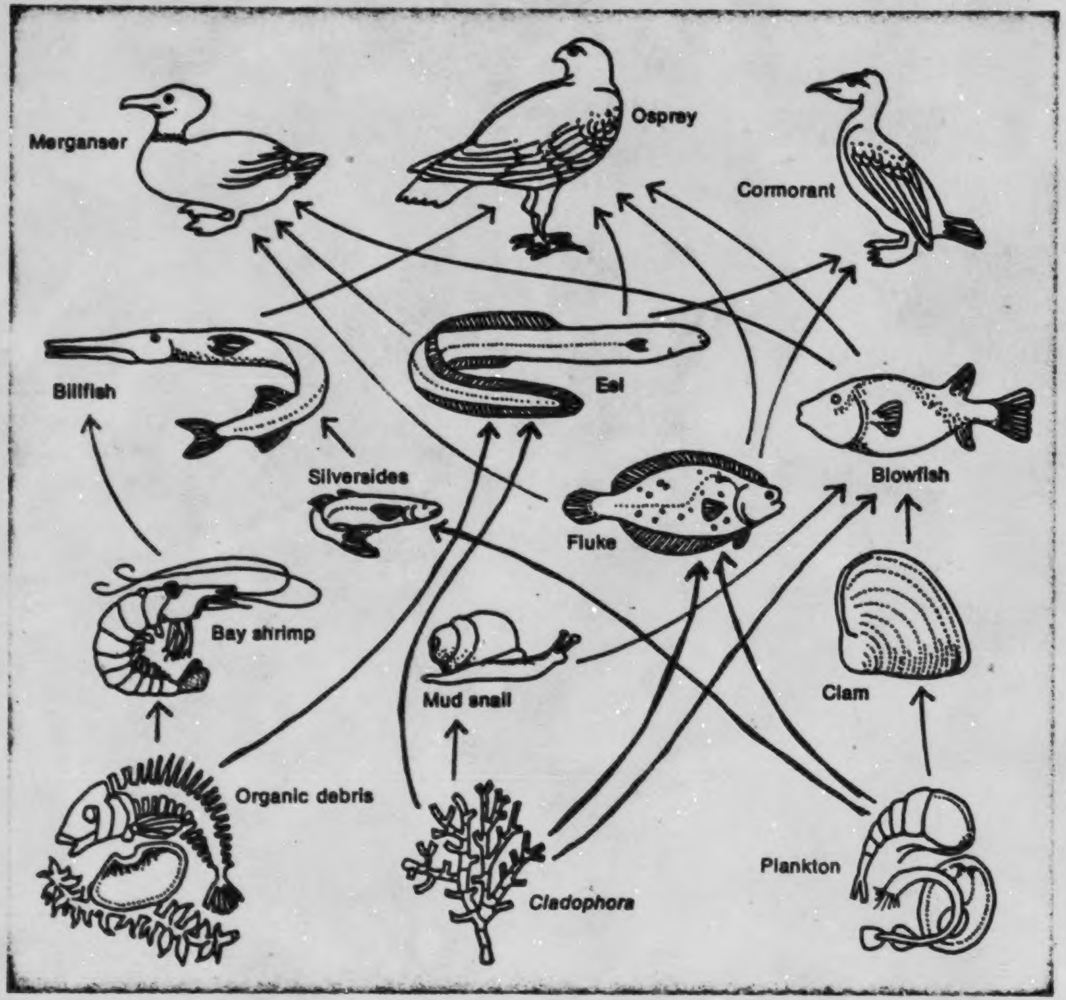
Figure 4-4



☐**4-10.** What harm might result from the accumulation of nonbiodegradable chemical wastes in water supplies?

In the late fall of 1960, large numbers of fish began dying along the southern portion of the Mississippi River. Since that time, millions of fish have died in similar situations. In addition, birds of prey such as the osprey and certain other fish-eating birds have decreased in number. The brown pelican, the state bird of Louisiana, has disappeared from that state's shores. The eggs of fish-eating birds often have thin, soft shells. As a result, the young birds don't hatch.

Figure 4-5



Merganser
Osprey
Cormorant
Billfish
Eel
Silversides
Fluke
Blowfish
Bay shrimp
Mud snail
Clam
Organic debris
Cladophora
Plankton

Careful chemical analysis of the bodies of the dead fish and birds has shown that quantities of chemical insecticides, such as DDT, are present in them. It is now known that these pest poisons (pesticides) have killed or weakened many millions of fish and birds. How does this happen?

Many pesticides are nonbiodegradable. They are carried by water runoff into streams, lakes, rivers, and oceans, where they may accumulate. These poisons may then be passed along as one organism feeds on another. Figure 4-5 illustrates what is commonly referred to as a *food web*. It shows which organisms serve as food input for other organisms.

☐**4-11.** The osprey and other preying animals suffer more ill effects from nonbiodegradable chemicals than do the plants and animals that they feed upon. How do you account for this? (Figure 4-6 may help you answer this question.)

The amount of nonbiodegradable chemical stored in a small plant or plant part is relatively small. But small animals may eat many plants. Thus, more nonbiodegradable chemical gets stored in the small animal than in the plant. Larger animals eat many smaller ones. Because of their larger diet, larger quantities of nonbiodegradable chemicals are taken in and concentrated in their bodies. Figure 4-7 shows the relative buildup of the concentration of one nonbiodegradable chemical by the organisms of the food web shown in Figure 4-5. This particular chemical is DDT.

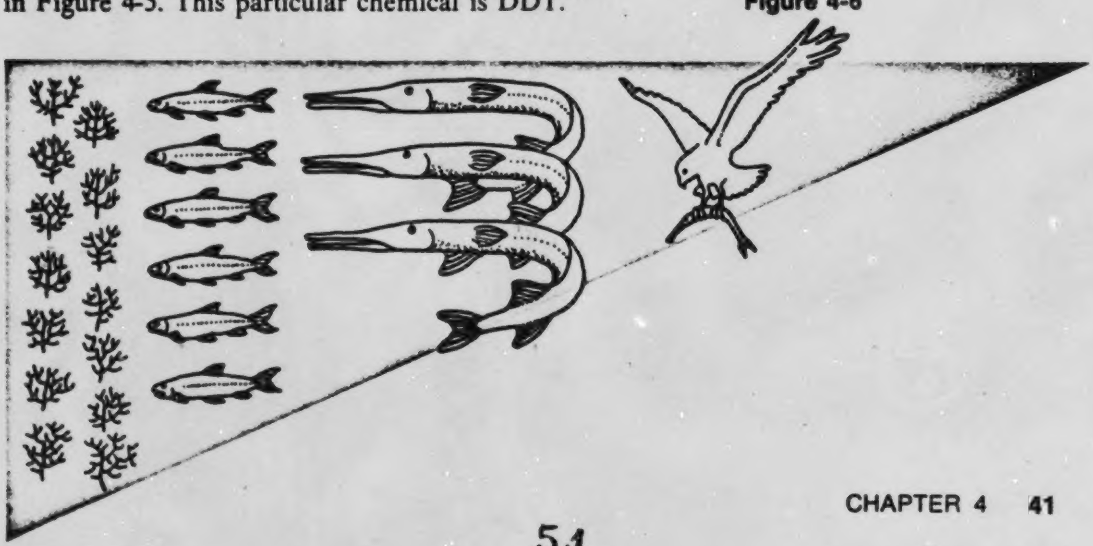


Figure 4-6

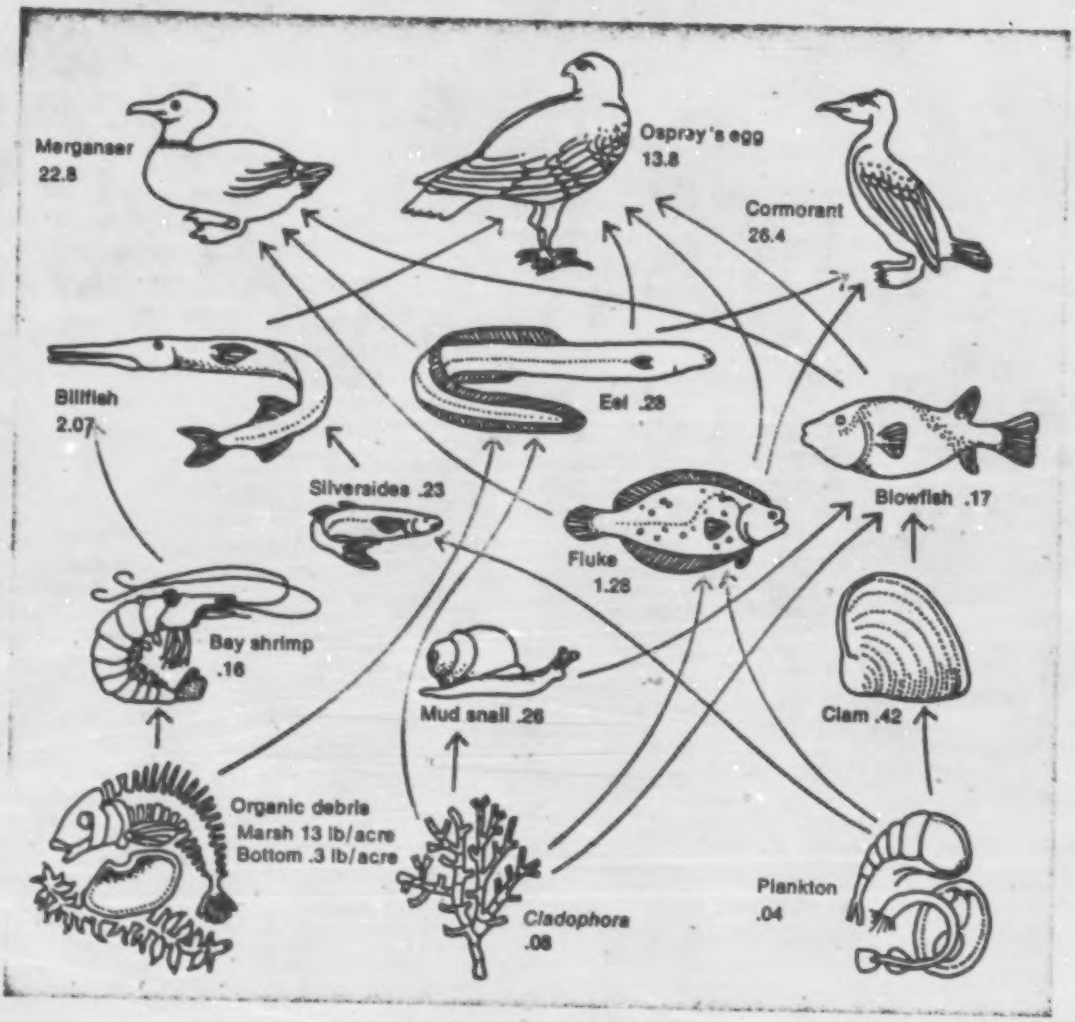

Merganser
22.8
Osprey's egg
13.8
Cormorant
26.4
Billfish
2.07
Eel .28
Silversides .23
Fluke
1.28
Blowfish .17
Bay shrimp
.16
Mud snail .26
Clam .42
Organic debris
Marsh 13 lb/acre
Bottom .3 lb/acre
Cladophora
.08
Plankton
.04

Figure 4-7

☐**4-12.** The federal Food and Drug Administration has banned fish taken from certain rivers and lakes in the United States as unsafe for human consumption (not safe to eat). Explain why this action is necessary.

☐**4-13.** What animals, other than fish, are likely to transfer pesticides to the human body?

☐**4-14.** Do you and your family contribute to pesticide pollution? If so, what can you do to reduce, or eliminate, this contribution?

PROBLEM BREAK 4-4

You've just seen some data that show that nonbiodegradable chemicals can be very harmful to organisms that are not pests. Because of this, some people think all pesticides should be totally banned. Others believe this would be disastrous. They point out that without pesticides the production of needed crops to feed an already hungry world would be greatly reduced. Discuss both sides of this argument with your classmates. Then write a summary of the arguments for and against banning pesticides.

PROBLEM BREAK 4-5

Plant fertilizers are not considered as poisons, yet they may contribute to the death of a lake or stream. Should fertilizers be banned in areas where they contribute to water pollution? List the arguments for and against the use of plant fertilizers such as phosphates and nitrates.

In this chapter you've seen how introducing nonbiodegradable chemicals into surface waters can affect living things. These effects are the result of two basic characteristics of chemicals (see points 1 and 2 on page 37). The effects do not end with just those organisms living in the water. You've also been reminded of the effect some substances have on the biological oxygen demand of plants and animals. In both cases, man has produced environmental changes that affect other living things, as well as himself.

In the next chapter, a different kind of man-made change will be discussed. This environmental change is due to heat.

Before going on, do Self-Evaluation 4 in your Record Book.

Figure 4-8

Getting All Steamed Up

Chapter 5

Increasing the concentration of reactants increases the speed of a chemical change. In Chapter 3 you saw how this happens within the earth's surface waters. You found that an increase in the amount of sewage in the water increases the rate of reproduction of microorganisms. As a result, the rate at which oxygen is removed from the water increases. You saw some of the results that this could have on life in the water.

Perhaps you remember another factor that influences the *rate* at which chemical reactions occur. If you've studied Volume 2 of ISCS, you may recall that *temperature* also influences reaction rates.

☐**5-1.** In what way does temperature affect the rate of a chemical change?

As you know, man adds heat to his surroundings from his body and from his fires. Though this added heat may at first not seem important, it really is. For example, huge quantities of water must be heated to steam each day to produce electricity. This water is taken from great rivers and lakes. After the water has been heated to steam and then used to drive turbine generators, it cools a bit and changes back to liquid water. This hot liquid is then pumped through an outlet pipe back into the river or lake from which it came.

This large quantity of heated water dumped into lake, river, or ocean may be free of chemical pollutants. However, because it is still hot, the temperature of the water near the power plant outlet can be raised several degrees Celsius above the normal temperature. What effect would this heating of the surface water have on animals and plants?

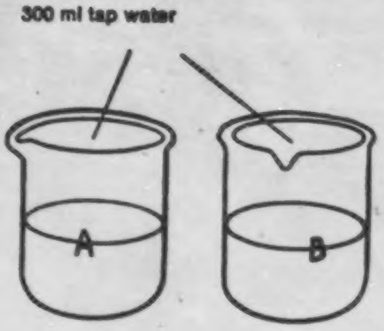
In the following activity you will be given a chance to collect the data necessary to answer that question. Goldfish, or minnows, will be the experimental animals you will use. You will test the effect that mild heat has on them.

Working with a partner, you will need about 30 minutes and the following materials:

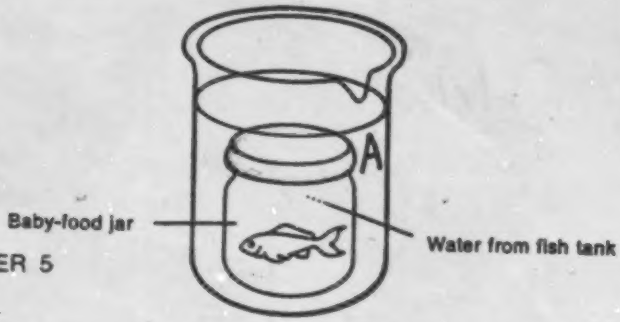
2 containers (coffee cans or large beakers)
1 alcohol burner
1 burner stand
1 timer, or watch with second hand
1 baby-food jar and lid
1 goldfish or minnow
1 dip net
1 thermometer

Caution *It is extremely important that you use only clean glassware when working with living things. Contaminated equipment can mean certain death for your fish. To be sure your glassware is clean, wash it thoroughly with water before you begin the activities. Do not use soap or detergents. Also, pay very close attention to the instructions in each activity. This will be a matter of Life and Death—for the fish.*

ACTIVITY 5-1. Place about 300 ml of tap water in each of two containers. Label the containers "A" and "B."



ACTIVITY 5-2. Fill a baby-food jar almost to the very top with water from the fish tank. Using a dip net, add one fish from the "ready" tank to the jar. Cap the jar and place it in container A.



ACTIVITY 5-3. After a few minutes, record in Table 5-1 the temperature of the water in container A. Then determine the relative activity of the fish by counting the number of breathing movements (opening and closing of the mouth or gills) that occur in 20 seconds. Have your partner time you as you count. Take at least three complete 20-second counts and find the average. Record all measurements in Table 5-1. Be patient—your fish may move about and interrupt your counting. If so, start your count over again.

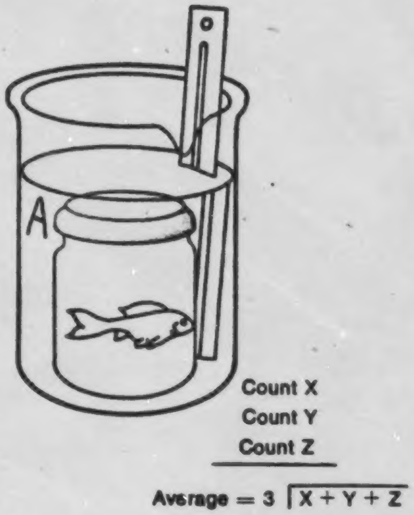
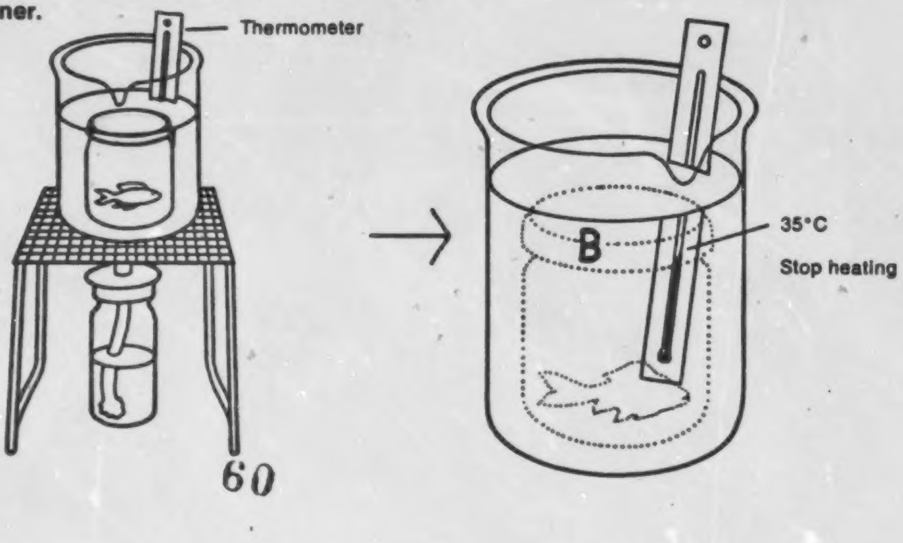
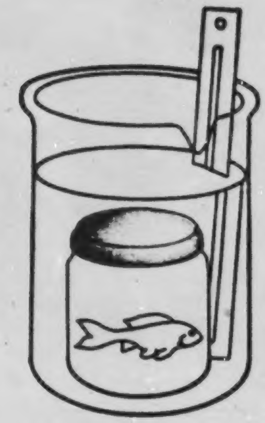


Table 5-1

Container	Temperature	Activity (respiration for 20 sec.)	Average Count	Other Observations
A		1. 2. 3.		
B		1. 2. 3.		

ACTIVITY 5-4. Place the jar with the fish into container B. Heat the container and its contents. When the water is 35°C (no hotter), remove the burner.





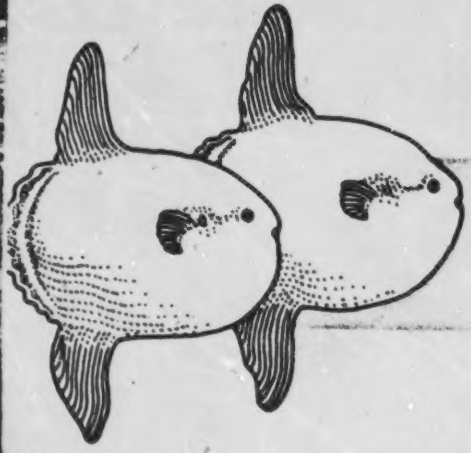
ACTIVITY 5-5. Now, determine the activity of the fish as you did in Activity 5-3. Record in Table 5-1 these data and any other observations you make of the behavior of the fish. Again, be patient in observing your fish. It may take a while to get three 20-second counts.

When you have completed the activity, put the fish into the "rest" tank so that another student won't use it right away.

☐**5-2.** How did the breathing rate of the fish in warm water compare to that of the fish in the cooler water?

☐**5-3.** Did the fish seem more active in the warmer, or in the cooler, water?

A fish is *cold-blooded,* which means that its body temperature adjusts to the same temperature as that of the surroundings. A *warm-blooded* animal is one whose body temperature stays about the same even when the temperature of the surroundings changes.



☐**5-4.** Would you be classified as warm-blooded, or cold-blooded?

☐**5-5.** Suppose an ocean sunfish had been swimming north from Florida, staying in the warm Gulf Stream. And suppose it entered the much colder water near the Maine coast. What do you predict would be the effect of the colder water on the fish's temperature? How would the fish's activity probably change?

Your observations probably showed that a fish is affected by changes in temperature. Increased breathing rate and greater activity result from increased temperature.

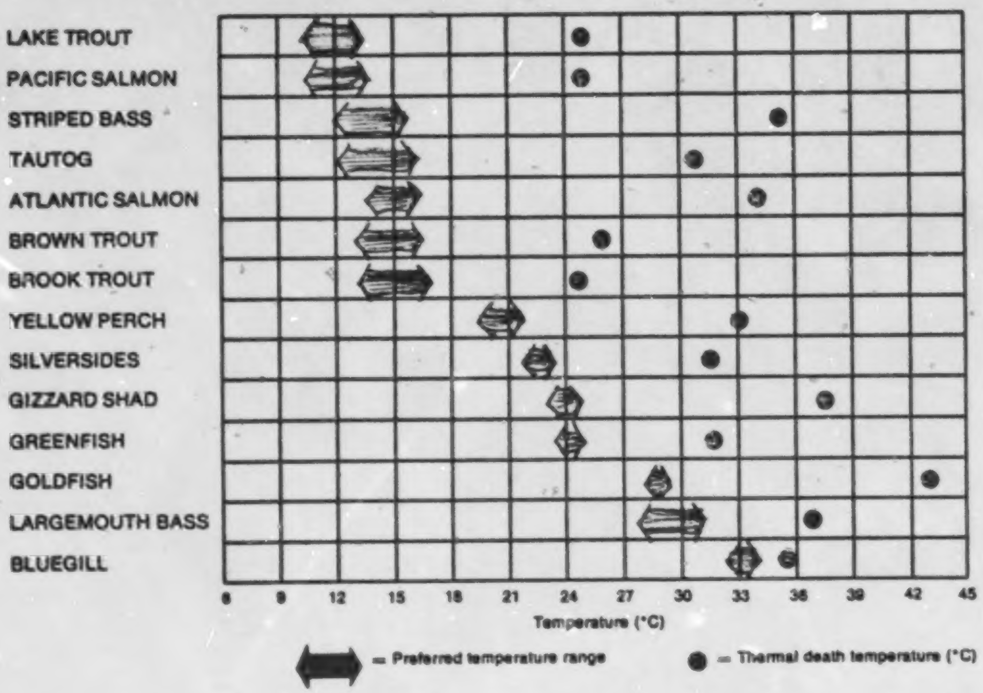
☐**5-6.** What do you predict would happen to the breathing rate if your fish were gradually cooled to a low temperature?

OPTIONAL ACTIVITY. You may want to find out whether your answer to question 5-6 is correct. If so, you should get your teacher's approval of your plan.

What do you predict would be the effect on fish other than goldfish or minnows of being placed in warm water? Would they react as your fish did? The answer is generally Yes. However, some fish are much more sensitive than others to increases in temperature. Examine Figure 5-1.

Figure 5-1 shows the range of temperatures preferred by various fish. It also shows the thermal death point (temperature at which they will die) for these fish. You examined the breathing rate of goldfish at 35°C. Eight degrees warmer, and your fish could have died.

Figure 5-1



☐**5-7.** Judging from Figure 5-1, what do you predict would have happened to a greenfish if you had heated its surroundings to 35°C?

☐**5-8.** In terms of temperature effects, why do you think goldfish make better pets than do brook trout?

You should be getting an idea of why adding heat energy to rivers, lakes, bays, and streams can present real problems for fish. But what about other aquatic (water) animals? The next problem break will give you a clue.

PROBLEM BREAK 5-1

A junior high student in California studied the effect of increased temperature on saltwater animals. The survival time of the animals was determined for different water temperatures. Table 5-2 contains the data.

Coastal waters near power plants may be up to 12°C warmer than the normal 9°–12°C range given in Table 5-2. Under such conditions, some of the animals would surely die. What would these animals have to do to survive? How would this upset the local balance of nature? Discuss your ideas with your classmates; then enter your conclusions in your Record Book.

Table 5-2

Group	H_2O Water Temperature (°C)	Cottids	Blennies	Hermit Crabs	Anemones
I (control)	9–12	All lived throughout the experiment.			
II	15	All lived two or three days.			
III	18	3 hr.	3+ hr.	5 hr.	5+ hr.
IV	21	1-2 hr.	1-2 hr.	1 hr.	5+ hr.
V	24	0.5 hr.	0.5 hr.	0.5 hr.	5+ hr.
VI	27	0.25 hr.	0.5 hr.	0.5 hr.	3 hr.

You have seen data showing that fish cannot survive in water above a certain temperature. The data in Table 5-2 also showed that other aquatic animals are sensitive to temperature changes. Actually, all animals are "temperature sensitive." Man is certainly no exception. He prefers a constant temperature of about 20–25°C. This is why he uses heaters in the winter and air conditioners in the summer.

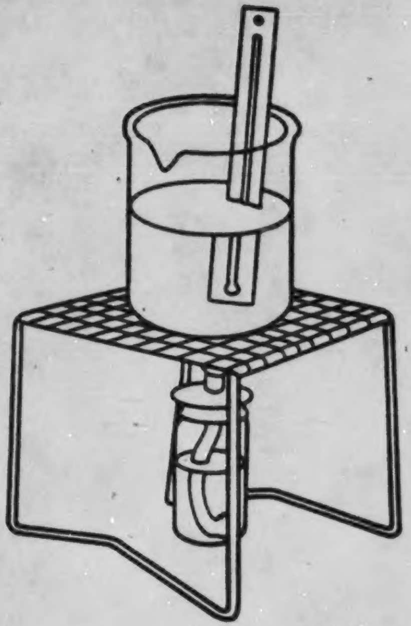
You probably recall that increased temperature increases the rate of chemical reactions. If you studied Volume 2 of ISCS, you also know that chemical reactions occur within living organisms.

☐**5-9.** How would the chemical reactions inside the fish be affected by increased water temperature?

To check your answer to question 5-9, you will need to do another investigation. You should try to find out if increased temperature affects the rate at which a living organism uses oxygen. Instead of using a fish, you will again use the microorganism yeast. You can follow a procedure similar to one you used in Chapter 3.

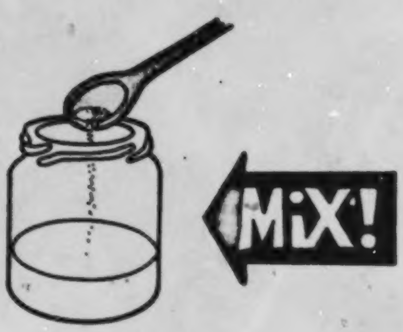
You and a partner will need about 20 minutes and the following materials:

Dry yeast
Powdered milk
1 dropper bottle of methylene blue solution
2 5-ml air pistons
3 test tubes (all the same size with capacity of at least 10 ml)
1 test-tube rack
1 stirring rod
1 plastic spoon
1 250-ml beaker
1 burner stand
1 alcohol burner
2 baby-food jars
1 timer or watch
1 thermometer
1 wax marking pencil

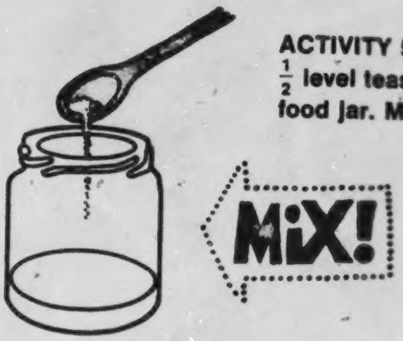


ACTIVITY 5-6. Begin heating a 250-ml beaker half filled with water. You may then go on to the next activity, but keep an eye on the beaker. When the water temperature is at 40°C, remove the burner.

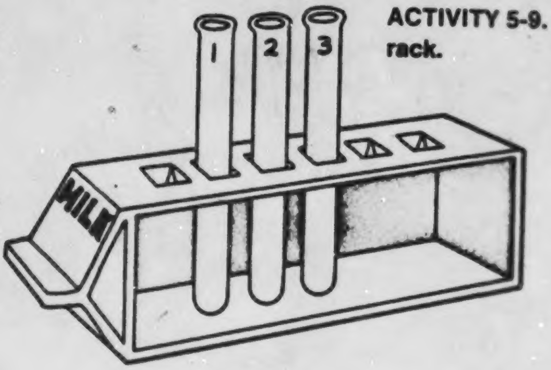
ACTIVITY 5-7. Prepare a sample of milk by adding $\frac{1}{2}$ level teaspoon of powdered milk to 20 ml of water in a baby-food jar. Mix thoroughly.



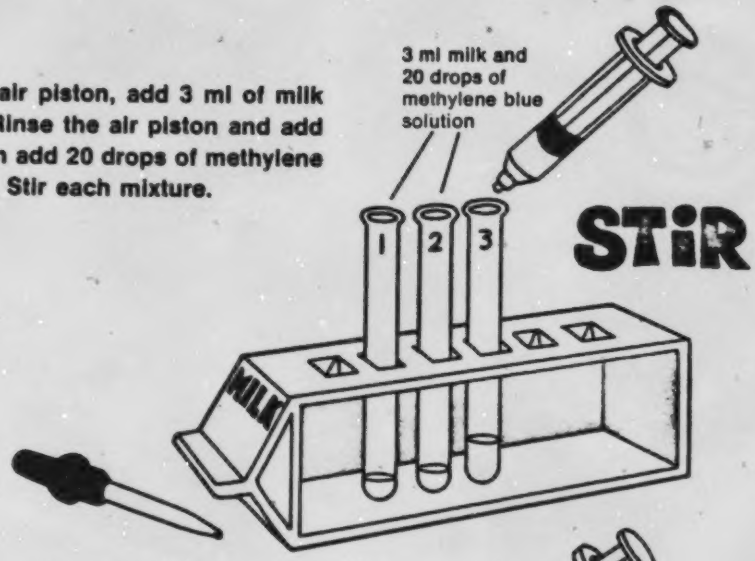
ACTIVITY 5-8. Prepare a sample of yeast solution by adding $\frac{1}{2}$ level teaspoon of yeast to 10 ml of water in the other baby-food jar. Mix thoroughly.



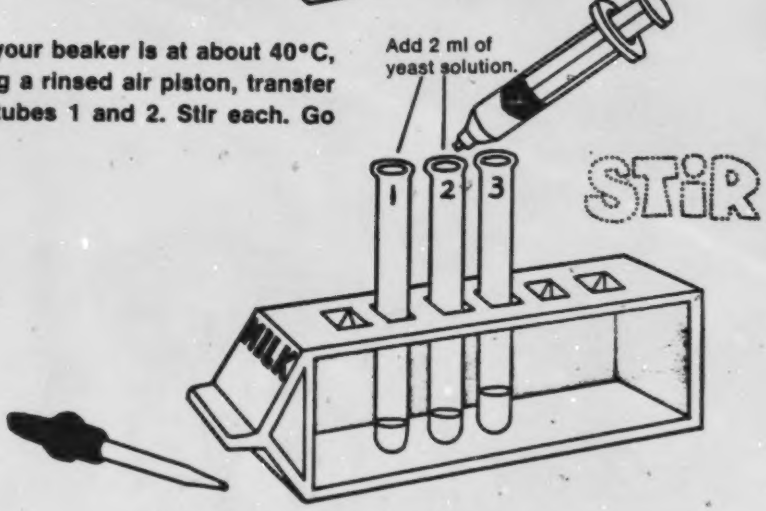
ACTIVITY 5-9. Place three labeled test tubes in your test-tube rack.



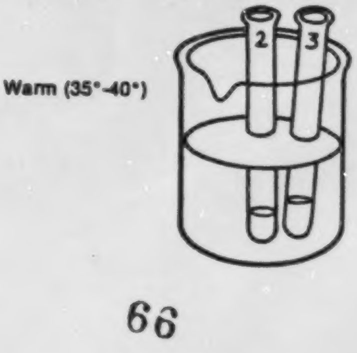
ACTIVITY 5-10. Using the 5-ml air piston, add 3 ml of milk solution to test tubes 1 and 2. Rinse the air piston and add 5 ml of water to test tube 3. Then add 20 drops of methylene blue indicator to each test tube. Stir each mixture.


3 ml milk and
20 drops of
methylene blue
solution
1
2
3
STIR
MILK

ACTIVITY 5-11. If the water in your beaker is at about 40°C, you are ready to proceed. Using a rinsed air piston, transfer 2 ml of yeast solution to test tubes 1 and 2. Stir each. Go quickly to the next activity.


Add 2 ml of
yeast solution.
1
2
3
STIR
MILK

ACTIVITY 5-12. Quickly put test tubes 2 and 3 into the beaker of warm water. Record the time in both rows of Table 5-3.


Warm (35°-40°)
2
3

GO

Observe each tube carefully. Watch for a complete color change (decolorization) in all three tubes. If it occurs, record the time in Table 5-3.

Table 5-3

Test Tube No.	Temperature (C°)	Starting Time from Activity 5-12	Time When Color Disappears	Total Time for Decolorization (minutes)
1	Room temperature (24-26°)			
2	Warm (35-40°)			
3	Warm (35-40°)			

☐**5-10.** Did the time for decolorization in test tubes 1 and 2 vary with the temperature? Why?

☐**5-11.** Did increasing the temperature increase the rate at which oxygen was used up by the yeast?

☐**5-12.** Test tube 3 was used for what purpose?

☐**5-13.** Did heating alone change the color of methylene blue?

☐**5-14.** Were the rates of the chemical changes in the yeast bodies affected by an increase in the temperature of the water?

☐**5-15.** Is it reasonable to assume that the rates of chemical changes in a fish's body would increase with increased temperature?

Living organisms use more dissolved oxygen when the temperature increases. This could account for the more rapid decolorization that occurred with the yeast in warmer water. However, there is another reason that decolorization occurred more rapidly in the heated water. Table 5-4 should give you a clue.

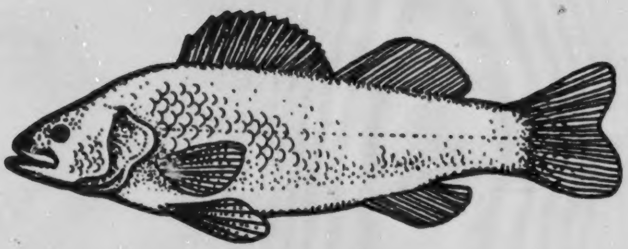


Table 5-4

Temperature °C	Amount of Oxygen Gas That Will Dissolve in Water (gm/100 ml)
0	0.0069
10	0.0054
20	0.0043
30	0.0036
40	0.0031
50	0.0027
60	0.0023
70	0.0019
80	0.0014
90	0.0008
100	0.0000

☐**5-16.** Living organisms use more oxygen in warm water than in cold. According to the data in Table 5-4, what other factor causes the oxygen supply to be used up more rapidly in warm water than in cold?

Increasing the temperature of surface water increases the biochemical oxygen demand of living things. It also decreases the amount of dissolved oxygen.

☐**5-17.** If an aquatic animal required a lot of oxygen, would you expect to find him living in cold, or warm, water? Why?

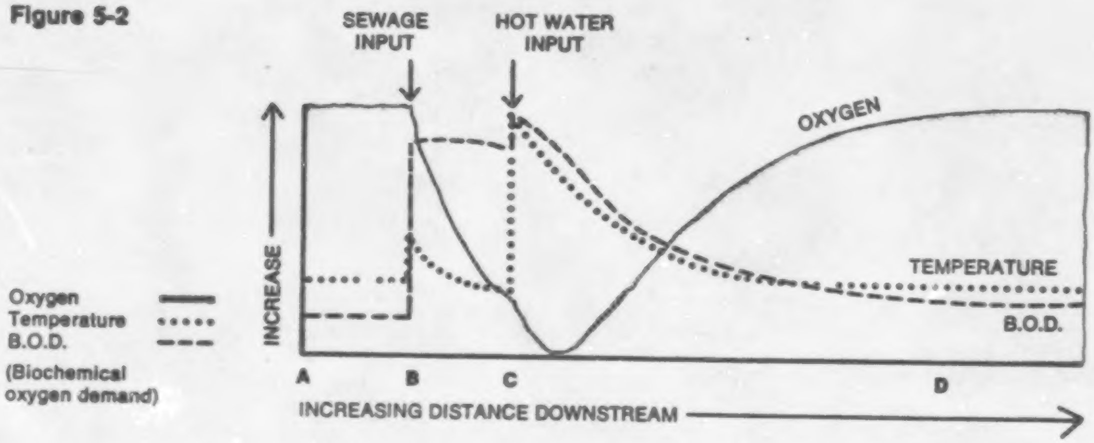
☐**5-18.** Where would you expect to find more life, in warm or in cold water? Explain your answer.

☐**5-19.** What effects do you predict heat pollution would have on living organisms in surface waters?

PROBLEM BREAK 5-2

Examine Figure 5-2 below. It summarizes data obtained from studying a polluted river. The vertical scale carries the single label "increase" and no units because the three graph lines are for different things. A line sloping upward means an increase in whatever the line represents. A down-sloping line shows a decrease in whatever it represents. (The key in the margin identifies each graph line.)

Figure 5-2



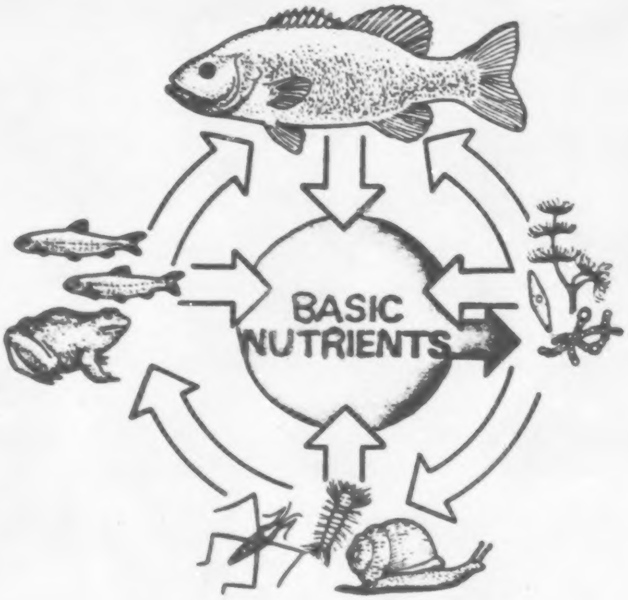
Between points **A** and **B**, you see the natural oxygen level, temperature, and biochemical oxygen demand (B.O.D.) in the river before it is polluted with sewage. At point **B**, sewage is dumped into the river; and at **C**, hot water is added.

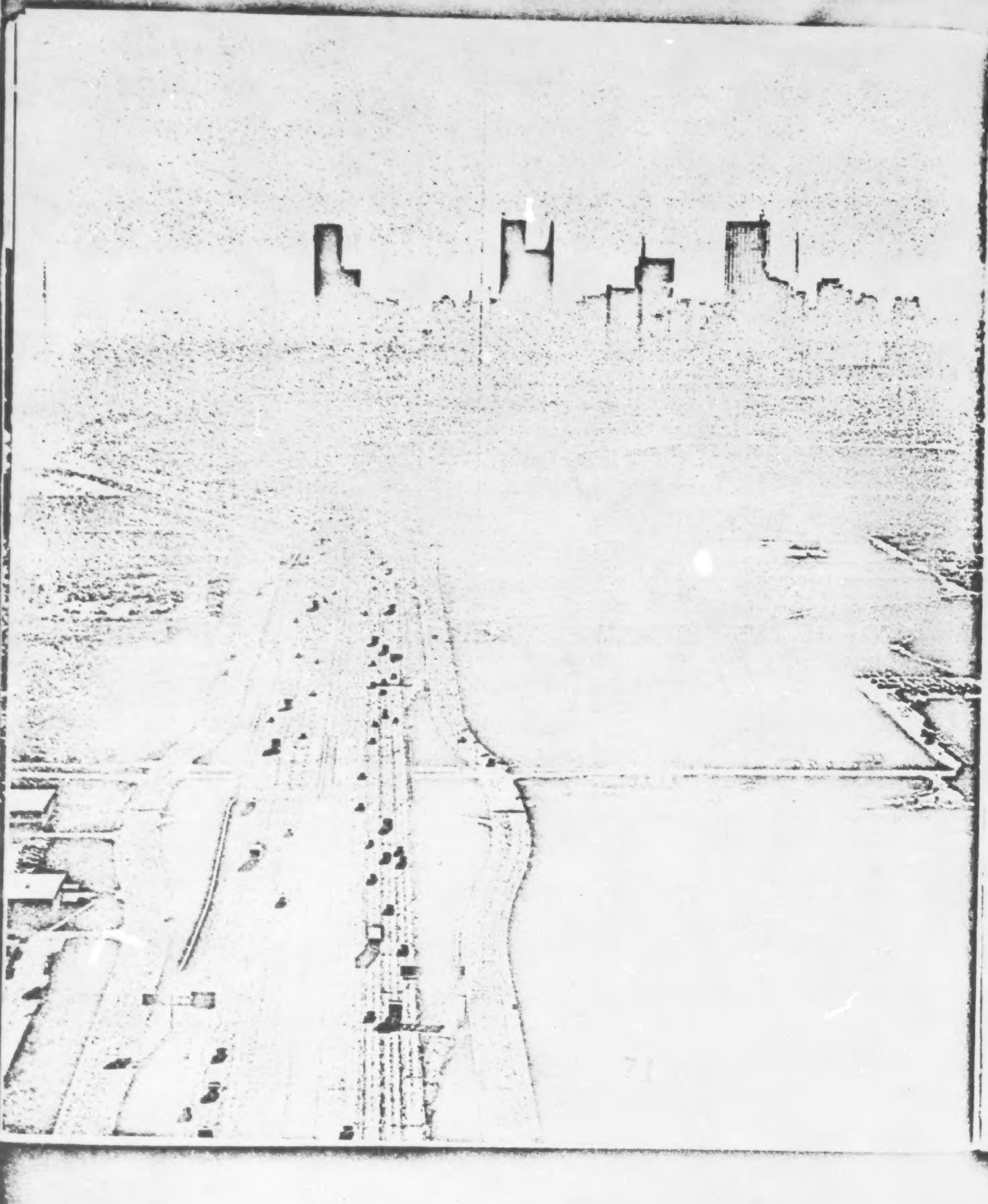
Using the graph, answer the next six questions, recording your complete answers in your Record Book.

1. What happened to the oxygen content when the sewage was dumped into the river? Explain why this happened.
2. What happened to the oxygen content of the water when heated water entered the river? Explain your answer.
3. At what two points was there an increase in the river water temperature?
4. What happened to the B.O.D. when the sewage was added to the river? Explain why this happened.
5. What happened to the B.O.D. in the warmer water? Explain why this happened.
6. Explain the change in the oxygen content, the B.O.D., and the temperature by the time water has moved downstream to point **D**.

As you've seen in this chapter, accumulation of heat in surface waters can produce important changes in the aquatic environment. This heat buildup is called *thermal pollution.* Combined with his output of sewage and other chemical pollutants, man's thermal pollution is seriously upsetting balanced systems of plants and animals. Because man is part of the system, he too is affected by the environmental changes he causes. The food he eats and the water he drinks carry the results of his own pollution back to him.

Before going on, do Self-Evaluation 5 in your Record Book.



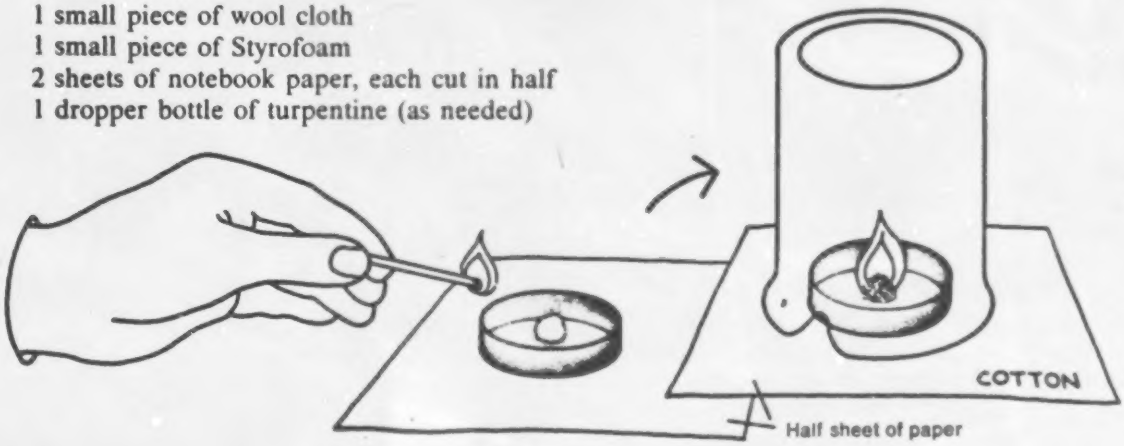


Sick Air?

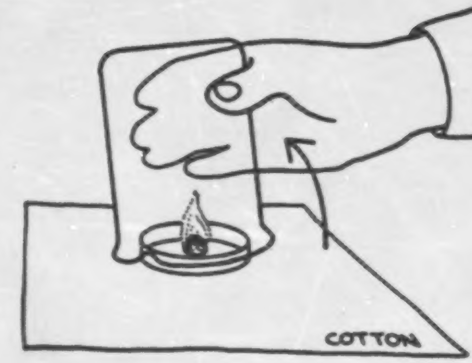
Chapter 6

Air pollution, along with water pollution, is a major problem for our nation. Factories steadily belching smoke, trash dumps endlessly smoldering, and backyard incinerators burning intermittently have added millions of tons of waste materials to the atmosphere. What are these wastes like? And what effects do they have on the environment? To start finding out, you and a partner will need about 30 minutes and the following materials:

1 book of safety matches
1 600-ml beaker or large jar
1 small lid (from a baby-food jar)
2 small wads of cotton
1 small piece of wool cloth
1 small piece of Styrofoam
2 sheets of notebook paper, each cut in half
1 dropper bottle of turpentine (as needed)



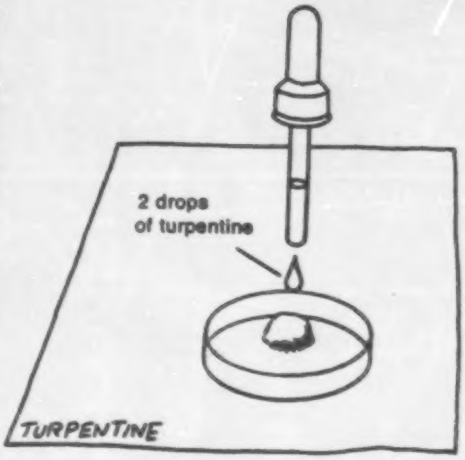
ACTIVITY 6-1. Place a small wad of cotton in the center of the lid. Place the lid on a clean half sheet of notebook paper. Label the paper "Cotton." Light the cotton and invert the 600-ml beaker or jar over the lid.



ACTIVITY 6-2. If the flame begins to die before the cotton is burned, lift the beaker slightly to let more air into the beaker. Then replace the beaker on the paper. Observe the beaker and its contents for two minutes after the flame goes out. Record all your observations in Table 6-1 in your Record Book.

When describing the products of burning, include the following: kinds of products; color; odor; whether it is a solid, liquid, or gas; and the appearance of whatever remains on the paper and lid after each burning. Be sure each piece of paper is labeled. Clean the lid and beaker after each burning and before doing the next part of the activity.

ACTIVITY 6-3. Put two drops of turpentine on a fresh wad of cotton. Label a clean half sheet of paper "Turpentine." Then repeat the procedure in Activities 6-1 and 6-2.



TURPENTINE

Use the same general procedure for the wool cloth and the Styrofoam. Be sure to label and save each paper for comparison.

Table 6-1

Material Burned	Color and Odor of Smoke Produced	Description of Other Products of Burning	Other Observations
Cotton			
Turpentine and cotton			
Wool cloth			
Styrofoam			

If you want to determine the effects of burning samples of some other substances, be sure to get your teacher's permission first. You may then enlarge Table 6-1 and add your findings.

☐**6-1.** On the basis of your observations, which materials do you think would produce the most air pollution when burned?

Question 6-1 may seem easy at first. Deciding which substance produced the most smoke and the most unpleasant odor is not difficult. However, you may not be able to tell by looking and smelling whether or not harmful gases are being produced by some of the substances.

☐**6-2.** Which of the materials when burned produced the poisonous gas carbon monoxide?

You cannot, just by looking, tell what gases are produced from burning, except possibly for one. Yet even when something burns without producing black smoke, or any smoke at all, products are released. Of course, not all products are harmful.

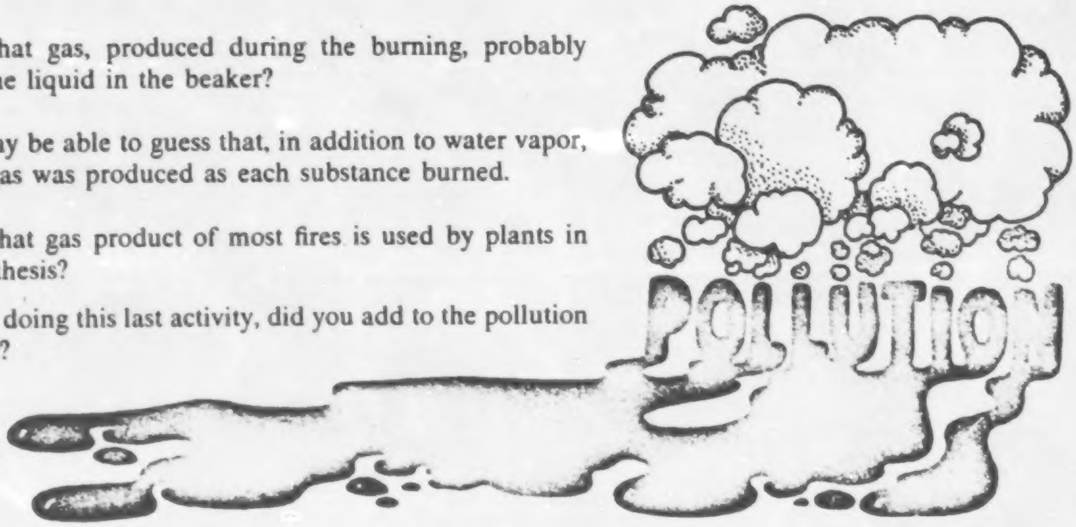
You probably noticed that a liquid formed on the inside of the beaker when one or more of the substances were burned.

☐**6-3.** What gas, produced during the burning, probably formed the liquid in the beaker?

You may be able to guess that, in addition to water vapor, another gas was produced as each substance burned.

☐**6-4.** What gas product of most fires is used by plants in photosynthesis?

☐**6-5.** In doing this last activity, did you add to the pollution of the air?



Americans place about 190 billion kilograms of waste materials into the air each year. Five sources account for most of the nationwide air pollution problem. Table 6-2 shows what these sources are and identifies some of the chemical wastes from each source.

Table 6-2

	POLLUTANTS (billions of kg)					
Source	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides	Sulfur Oxides	Solid Particulates	Total by Source
Transportation (cars, truck, buses, etc.)	58.1	15.9	6.9	0.3	1.1	82.3
Electrical power plants and heating	1.7	0.6	6.0	20.6	8.3	37.2
Industry	9.6	3.2	0.2	6.5	6.9	26.4
Refuse disposal	6.9	1.4	0.5	0.1	0.9	9.8
Misc. (forest fires, etc.)	15.2	7.4	1.6	0.6	8.7	33.5
Totals	91.5	28.5	15.2	28.1	25.9	189.2

☐**6-6.** What source produces the greatest amount by weight of air pollution?

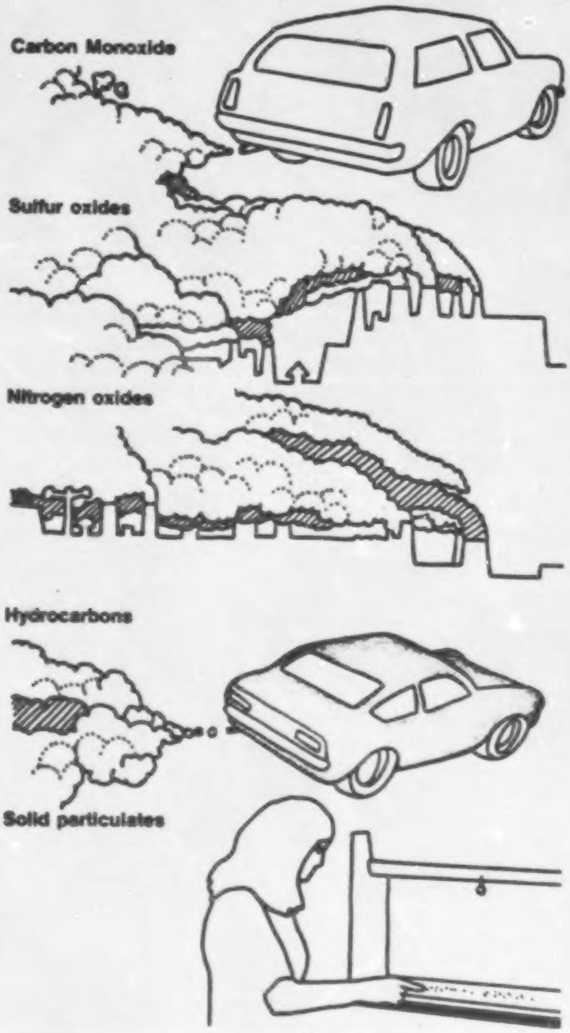
☐**6-7.** What source produces the most carbon monoxide?

☐**6-8.** If one wanted to reduce the solid particulates in the air, which sources would he have to confront?

☐**6-9.** What are the two main sources of sulfur oxides?

The information in Table 6-2 applies to the entire United States. There may be major differences in the sources of pollution products in a particular region. Perhaps you are not familiar with the types of pollutant products identified in Table 6-2. If so, the information in Table 6-3 should be helpful.

☐**6-10.** Which types of air pollutants listed in Table 6-2 directly affect man's health?



POLLUTANT	DESCRIPTION
Carbon Monoxide	This colorless, odorless gas, is often found in tunnels, closed garages, and near heavy traffic. It is produced when carbon-containing fuels are incompletely burned. Carbon monoxide reduces the ability of blood to carry oxygen. Large amounts are fatal; small amounts cause dizziness, headaches, fatigue, and slowed reactions.
Sulfur oxides	These poisonous gases come mainly from the burning of coal and oil containing the element sulfur. They irritate the eyes, nose, and throat; damage the lungs; kill plants; destroy metal; and reduce visibility.
Nitrogen oxides	Burning fuels produce most of these gases. They produce a smelly, dark haze that irritates the eyes and nose.
Hydrocarbons	These result mainly from unburned fuels during combustion. However, large amounts also are produced as tires wear. Hydrocarbons are known to produce cancer. Hydrocarbons react with nitrogen oxides and sunlight to produce smog.
Solid particulates	There are many forms of solid matter in the air—dust, smoke, soot, ash, etc. These particles may stay suspended or settle to the ground. They dirty many objects and darken the sky. Solid particles interfere with normal breathing.

Table 6-3

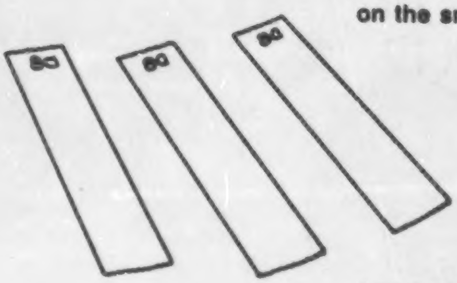
PROBLEM BREAK 6-1

How much air pollution is occurring in your own neighborhood or community? You can get a rough idea by simple observation. As you are on your way to and from school, observe any smoke you see. Try to locate its source. Find out what kind of material is being burned and the sort of smoke produced. Keep a record of your findings in your Record Book.

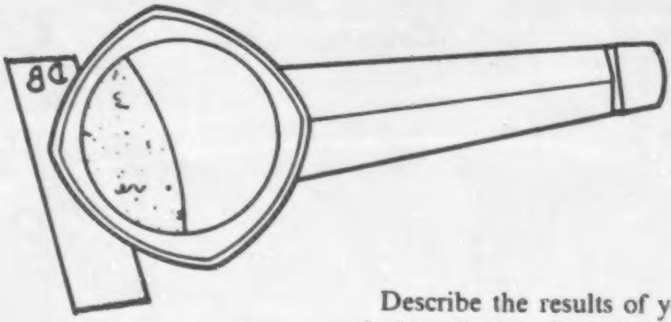
After a period of time, you may wish to discuss the results with some of your classmates. You may be surprised at how much smoke there is in your area when you start looking for it! But don't forget, not all air pollution is visible.

As you've seen, gases are not the only product of burning; various particles also result. In addition, dust and pollen add to the particulate content of air. Use the method of studying particulate pollution shown in Activities 6-4 and 6-5.

ACTIVITY 6-4. Place small pieces of tape (with the sticky side up) in two or three places around the room. Put your initials on the smooth side of each piece.



ACTIVITY 6-5. After a period of time, examine the strips with a hand lens or microscope to see what particles have collected.

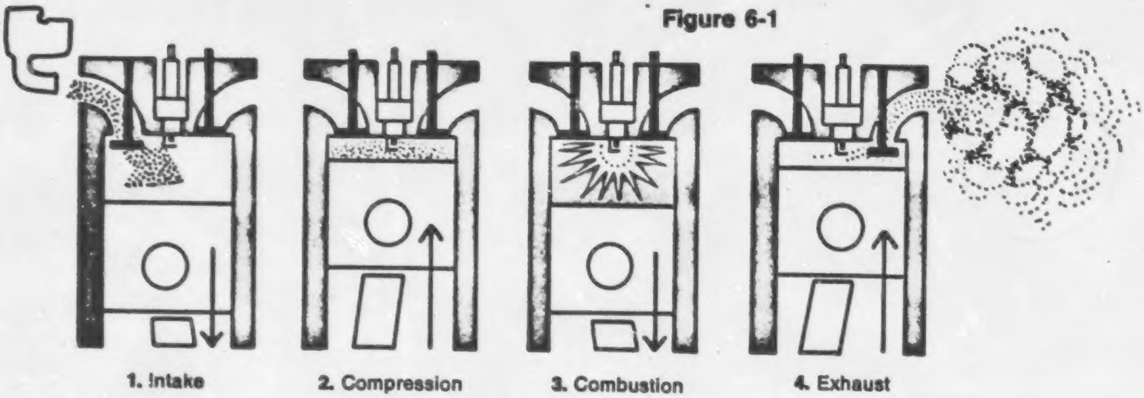


Describe the results of your investigation, and your conclusions, in your Record Book. You may want to try to locate the sources for the particles you collect.

From your activities so far in this chapter, you have seen that large amounts of air pollution can result from the burning of even small amounts of materials.

As you may know, automobiles and air pollution are closely related. Most cars have internal-combustion engines that operate somewhat like a small furnace. Chemical energy from burning fuel inside the engine provides the mechanical energy that moves the car. See Figure 6-1.

Figure 6-1



The internal-combustion engine is considered by some to be the single most important contributor to air pollution. Is such a statement justified? You can decide for yourself as you study the next two pages.

About 80 percent of American families own cars. And about 30 percent of families own two or more cars. There are also millions of trucks, buses, motorcycles, and taxis. Altogether, there are about 100 million motor vehicles in the United States today. See Tables 6-4 and 6-5.

Table 6-4

MOTOR VEHICLE REGISTRATIONS (millions)

	Date				
Type of Vehicle	1950	1955	1960	1965	1970*
Passenger cars, taxis	40.3	52.1	61.7	75.2	84.4
Trucks and buses	8.8	10.5	12.7	15.1	18.1
Motorcycles	0.4	0.4	0.6	1.4	2.5
Total	49.5	63.0	75.0	91.7	105.0

Number of vehicles estimated

AUTOMOBILE OWNERSHIP (By Year)*

	1950	1955	1960	1965	1970
No. of families (millions)	45.2	49.1	53.4	58.5	63.7
Families owning automobiles (%)	59	70	77	79	80
a. Families owning one automobile (%)	52	60	62	55	50
b. Families owning two or more automobiles (%)	7	10	15	24	30

**Excluding Alaska and Hawaii; figures for 1970 estimated*

Table 6-5

Use the information in Tables 6-4 and 6-5 to answer the following questions.

☐**6-11.** What was the increase in the total number of motor vehicle registrations between 1950 and 1970?

☐**6-12.** What was the increase in the total number of families owning cars between 1950 and 1970?

☐**6-13.** Based on the increase in the *number of cars* and the *number of families owning cars,* what do you predict will be the total number of cars in 1975?

☐**6-14.** What do you predict will be the percentage of families in 1975 that own two or more motor vehicles?

Remember, automobiles are powered by combustion. In this way, a motor vehicle is like a match or like a human: each one contributes its own output to the air, and each one requires inputs from the environment.

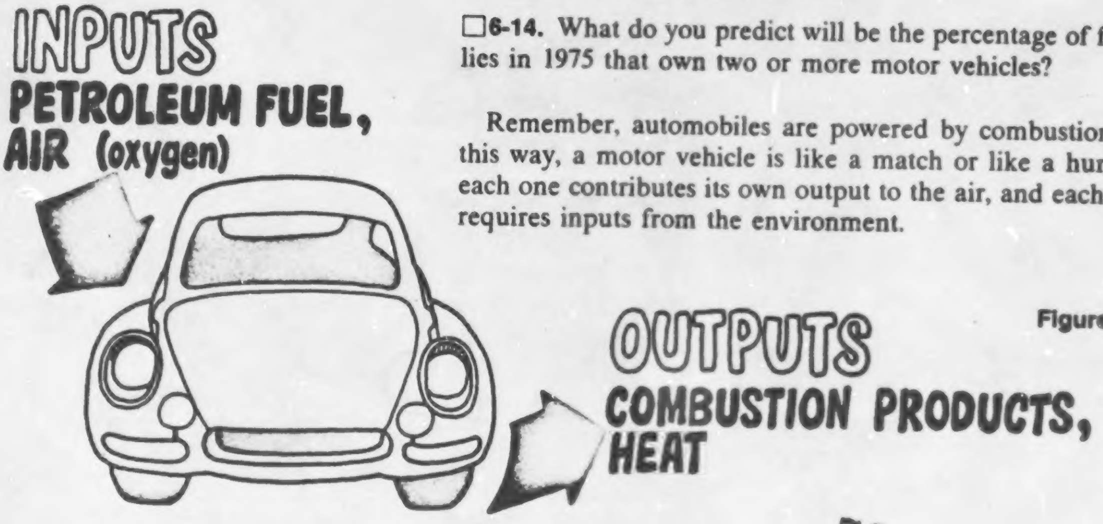


Figure 6-2

Study the data in Table 6-6 to see the effects a motor vehicle has on the surrounding atmosphere.

Table 6-6

AVERAGE OUTPUT OF AIR POLLUTANTS FROM MOTOR VEHICLE OPERATING AT ABOUT 40 km/hr

Source	Pollutant	Quantity of Output (g/liter of fuel)
Gasoline engines	Carbon monoxide	284.9
	Nitrogen oxides	22.2
	Hydrocarbons	15.8
	Solid particulates	1.3
	Sulfur oxides	1.0
Diesel engines	Hydrocarbons	21.6
	Solid particulates	13.3
	Nitrogen oxides	12.0
	Carbon monoxide	7.1
	Sulfur oxides	4.8

☐**6-15.** According to Table 6-6, what are the three most abundant pollutants from gasoline-powered vehicles?

☐**6-16.** What are the three most abundant pollutants from diesel-powered vehicles?

☐**6-17.** Which type of engine produces more solid particulates?

☐**6-18.** Estimates show that in a city of about 50,000 people, at least 76,000 liters of gasoline are burned by automobiles each day. According to the data in Table 6-6, how many grams of carbon monoxide would be added to this city's atmosphere each day?

It has already been said that carbon monoxide (CO) is a poisonous gas. The fact is, it can be a killer. Examine Figure 6-3.

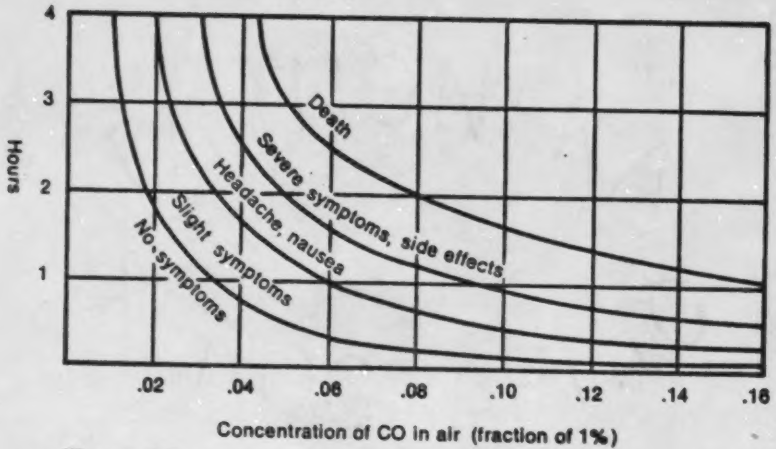
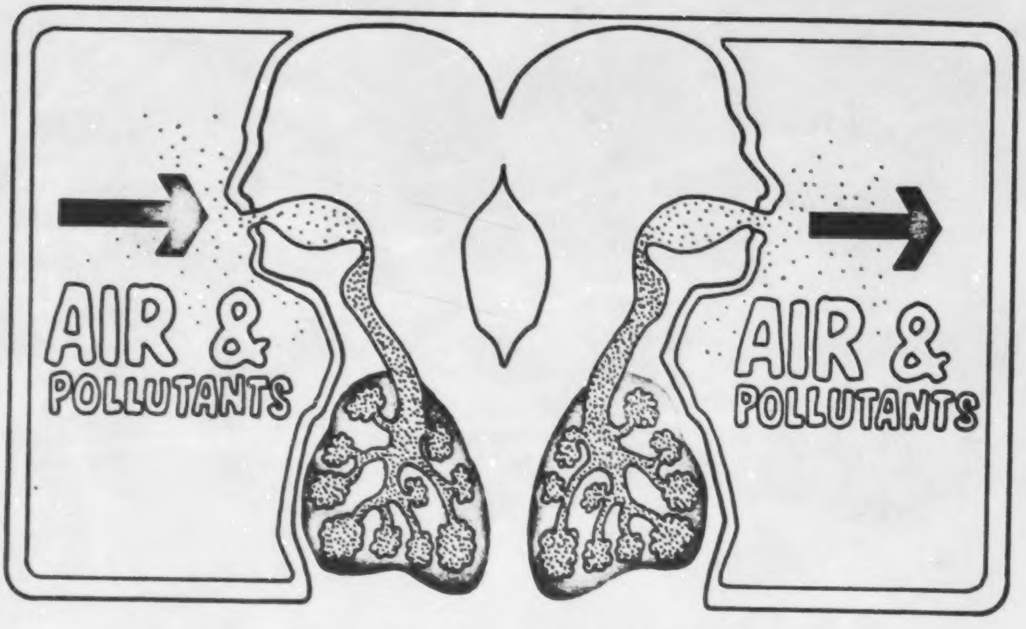


Figure 6-3

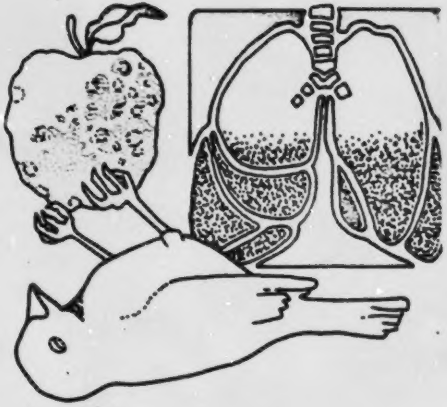
☐**6-19.** How long would a person have to be exposed to CO before death occurs if the concentration of the gas in the air is 0.06%? 0.12%? 0.15%? Man, as an input-output system, is seriously affected by air pollutants.

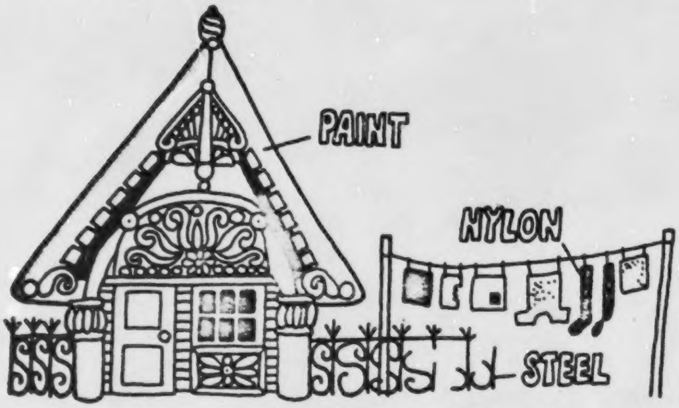
Figure 6-4


AIR &
POLLUTANTS
AIR &
POLLUTANTS

Anything that injures lung tissue is a hazard to life. Carbon monoxide and other air pollutants have been found to change some lung tissue. These changes in tissues may produce lung diseases such as bronchitis and emphysema—diseases that were rare twenty-five years ago. Much needs to be learned about the causes of these diseases. However, evidence indicates that air pollutants are at least partly responsible for them.

There are other bad effects that result from air pollution. Annual crop damage from air pollution is estimated at over $6,000,000,000. Thousands of domestic and wild animals are weakened or killed outright. Exact data on human death and disease are lacking, but it is clear that air pollution is especially dangerous for people with heart disease, asthma, emphysema, anemia, etc. Lung cancer is found twice as often in air-polluted cities as in rural areas.





Polluted air discolors and damages clothing, automobiles, and buildings. A major maintenance factor in polluted areas is the replacement of discolored and peeling paint. Steel deteriorates two to four times faster in air-polluted cities than in rural areas. Dirty air deteriorates rubber, glass, leather, nylon, paper, and even stone.

Incomplete combustion of fuels not only pollutes the air but wastes valuable resources. For example, more than $300,000,000 worth of sulfur is wasted annually. Industries are working hard on ways of reclaiming and using "waste" products. Pollution causes higher lighting and heating bills. For example, it is estimated that in Chicago on some days air pollution reduces sunlight by 40 percent.

POLLUTION
CONTROL

No area of the nation is free of air pollution. Therefore, air pollution is everyone's problem. And everyone contributes to it. It is estimated that air pollution costs the United States about $13,500,000,000 a year.

☐**6-20.** How much is your "share" of this cost? (Hint: Assume a U.S. population of approximately 210,000,000.)

In the last several chapters, you've studied air and water pollution. Both are particular problems in cities and towns. Yet neither form of pollution respects city limits. Air and water flow from one region to another, often carrying pollutants long distances from their source.

☐**6-21.** List all the ways that *you* contribute to the problem of air pollution.

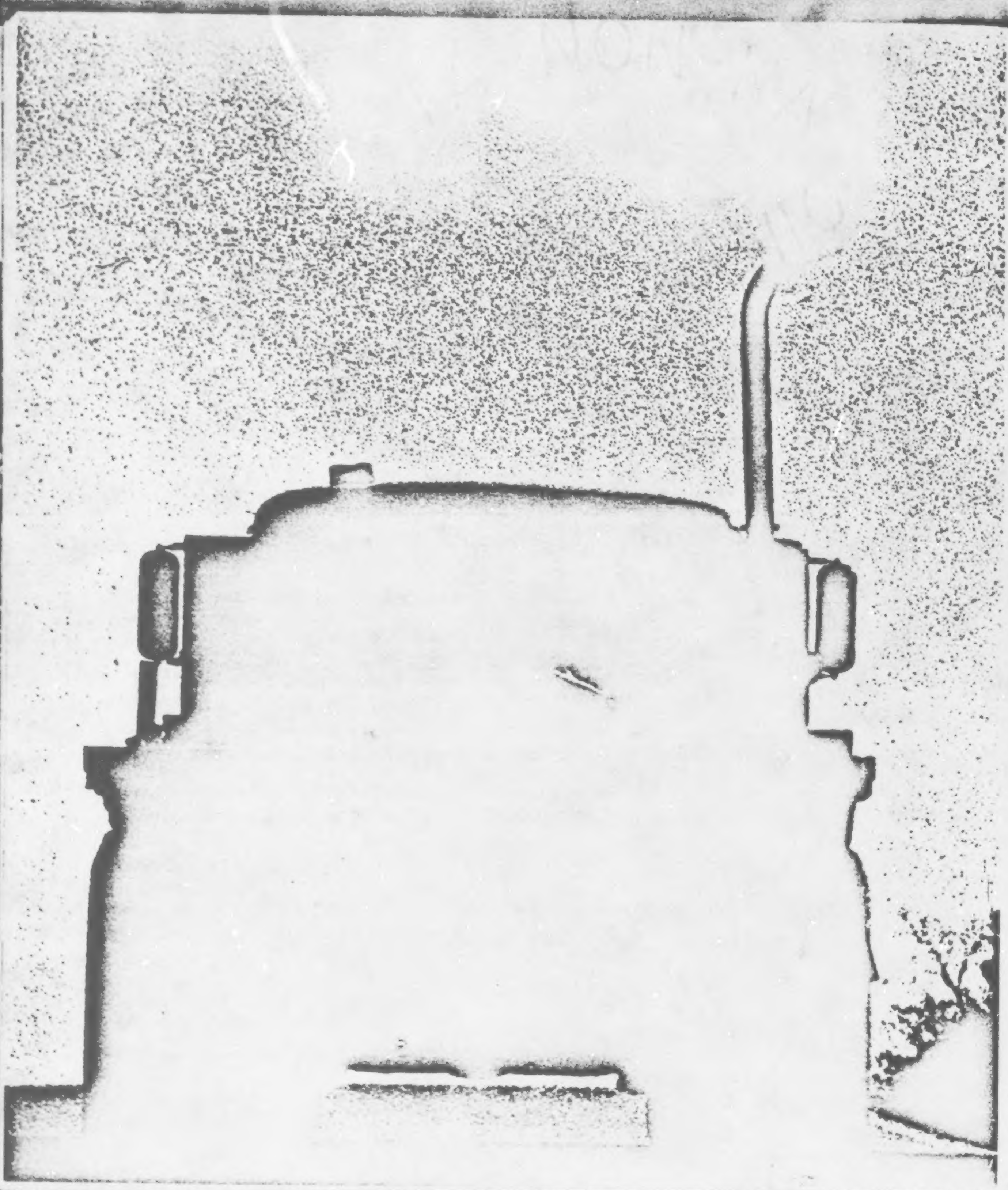
☐**6-22.** Describe how your contributions to air pollution might be reduced or eliminated.

Serious air-pollution crises have occurred in many U.S. cities and in other cities around the world. One of the most disastrous situations occurred in London, England. **Excursion 6-1** describes that crisis and helps explain how it happened.

◀EXCURSION

Fifty years ago, even fifteen years ago, few people were worried about the effects of pollution. Why is concern for the input-output relationship between man and his surroundings suddenly so important? Chapter 7 deals with this question by looking at what is happening to the world population.

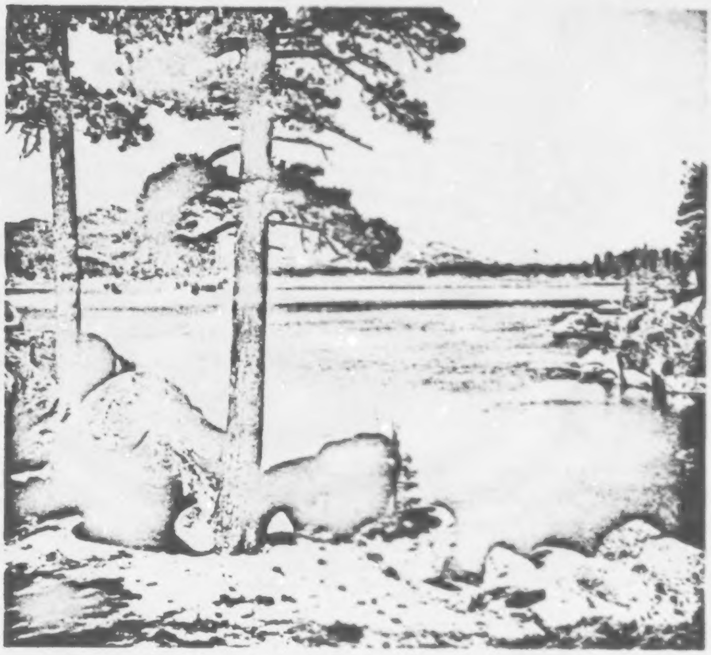
Before going on, do Self-Evaluation 6 in your Record Book.



The Environment Throws a Curve

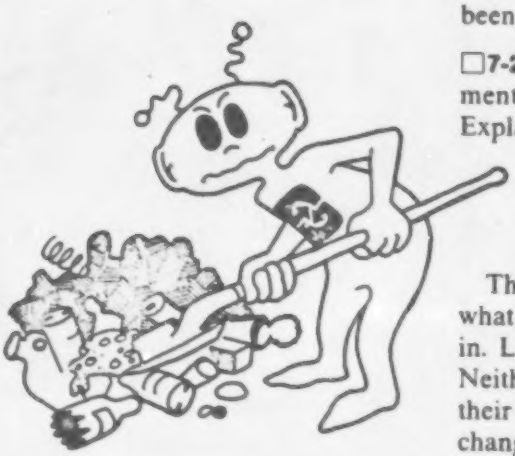
Chapter 7

Ever since man appeared on the earth, his activities have affected the input-output balance of living things and their surroundings. His most recent effects are perhaps the most outstanding. Lands, once forested, are now covered over with concrete and steel. Many bays, rivers, and lakes, once clear and filled with life, have shores spoiled by oil spillage and refuse. City air, at first clear, then hazy, is now smog-filled.



☐**7-1.** Why have man's greatest effects on the environment been the most recent ones?

☐**7-2.** Do you predict man's future effects on his environment will be greater than, or less than, those up to now? Explain your prediction.



The effect of people on their surroundings depends upon what they take from the environment and what they put back in. Living things cannot avoid changing their environment. Neither can groups of living things avoid being changed by their environment. The larger the size of the group, the more change it will produce. How has the size of the human group changed, and what will be the result of that change?

Table 7-1 shows what has happened to the world population since 8000 B.C. Plot this information on the grid in Figure 7-1 of your Record Book. Then draw a best-fit line.

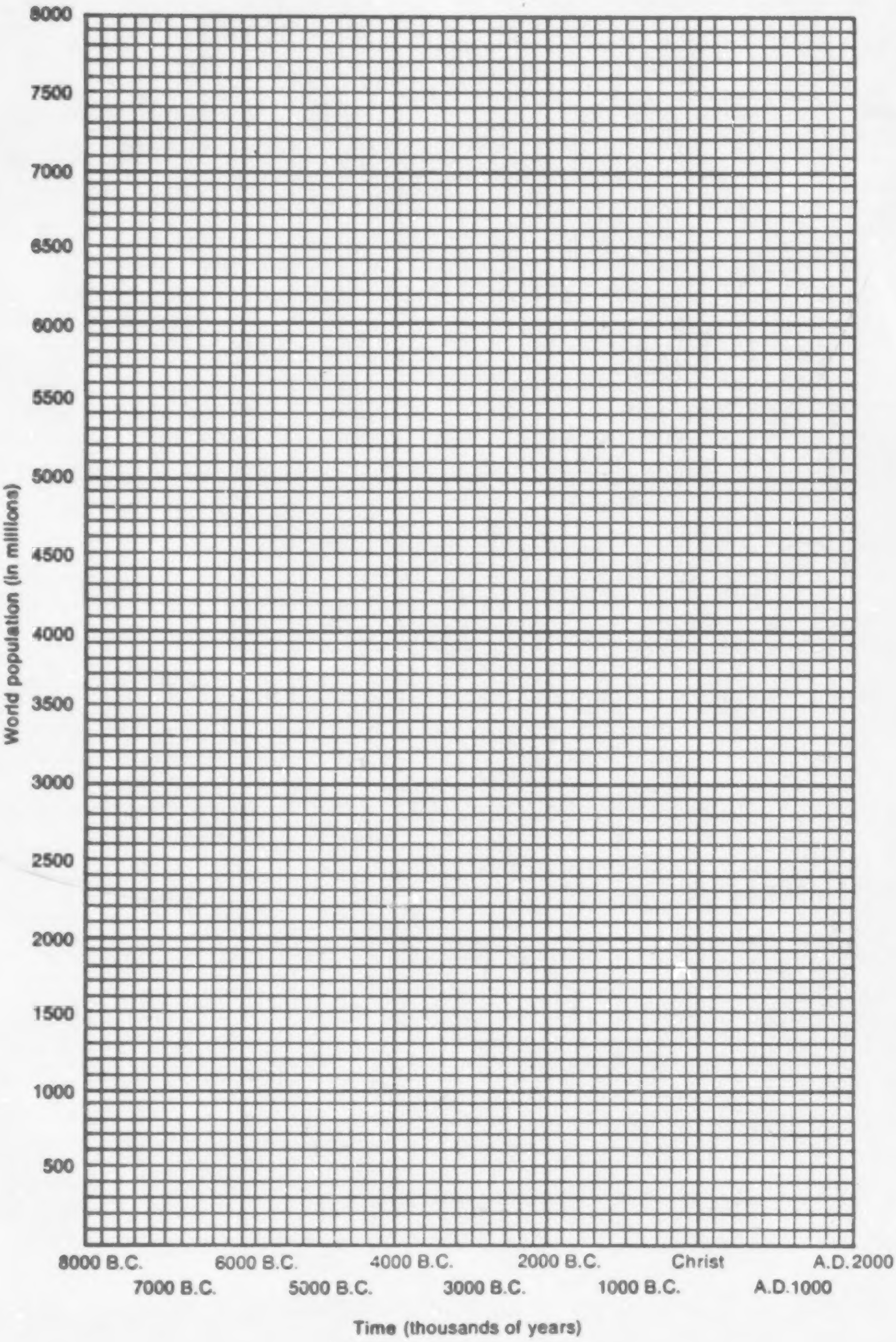
Table 7-1

WORLD POPULATION CHANGES

Date	Population (millions)*
8000 B.C.	5
4000 B.C.	75
2000 B.C.	150
Birth of Christ	250
A.D. 1650	500
A.D. 1830	1,000
A.D. 1930	2,000
A.D. 1960	3,000
A.D. 1970	3,600
A.D. 1975	4,000
A.D. 2000	7,500

**Estimated population*

Figure 7-1


World population (in millions)
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
8000 B.C.
7000 B.C.
6000 B.C.
5000 B.C.
4000 B.C.
3000 B.C.
2000 B.C.
1000 B.C.
Christ
A.D.1000
A.D.2000
Time (thousands of years)

☐**7-3.** According to your graph, what will the world population be by 2020?

You probably had trouble with the last question. It's not easy to answer from the graph. If the graph you drew in Figure 7-1 is a good one, the line near the right-hand side should have been about straight up! This rather startling prediction about population growth has led to the term *population explosion.* The population increase is occurring at an "explosive" rate.

☐**7-4.** Can the size of the world population of humans continue to increase from now on?

Perhaps you need more information to answer question 7-4. For example, is the human population explosion typical of other living organisms? Take a look at population growth in some other animal.

One common but very tiny animal frequently used in experiments is the paramecium. It reproduces by dividing. One animal divides to become two (Figure 7-2). Each of the new animals divides again, making four. Because parameciums live and reproduce in water, their population growth can be observed easily.

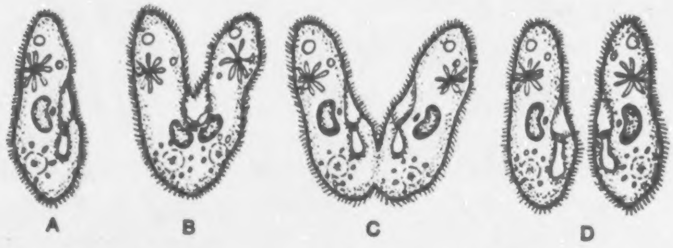


Figure 7-2

In one investigation, 0.5-ml samples of water were taken daily from a container in which there was a well-fed paramecium population. A microscope was then used to count the number of organisms in each 0.5-ml sample. Table 7-2 contains the results of thirteen days of investigation. Plot this information on the grid in Figure 7-3 in your Record Book and draw a best-fit line.

The paramecium population in the container certainly grew rapidly within one week. In those few days, it became eighty times larger than at the start.

	TIME (days)													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of parameciums in 0.5-ml sample	5	12	30	75	150	260	340	405	440	450	455	445	460	450

Table 7-2

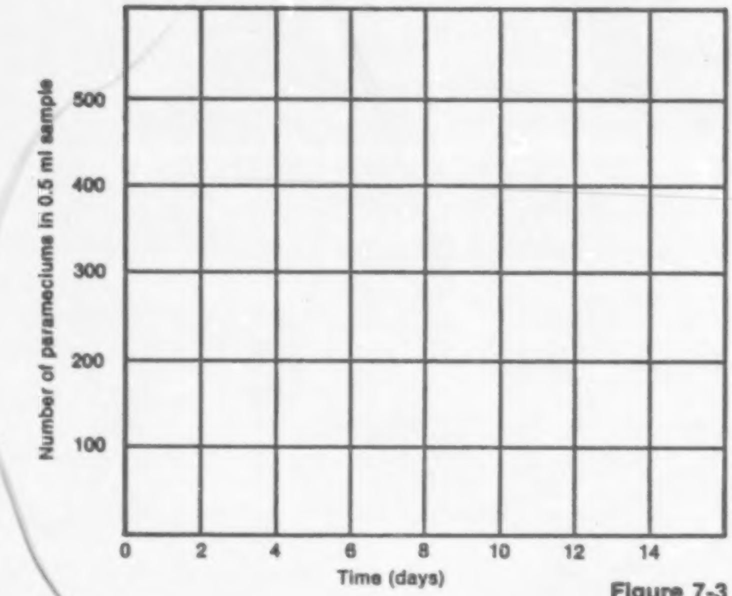


Figure 7-3

☐**7-5.** According to the graph, is the rate of population increase a constant?

☐**7-6.** What do you predict the population will be by the beginning of the fourteenth day?

☐**7-7.** On what day did the number of births first about equal the number of deaths in the population? How do you know?

If you completed Figure 7-3 successfully, the shape of the curve should have reminded you of the letter S. This S-shaped curve has been found in population studies of many plants and animals. Because of this, it is often called a population curve. Figure 7-4 shows a typical population curve.

The letters **A** and **B** have been added to identify certain points on the curve.

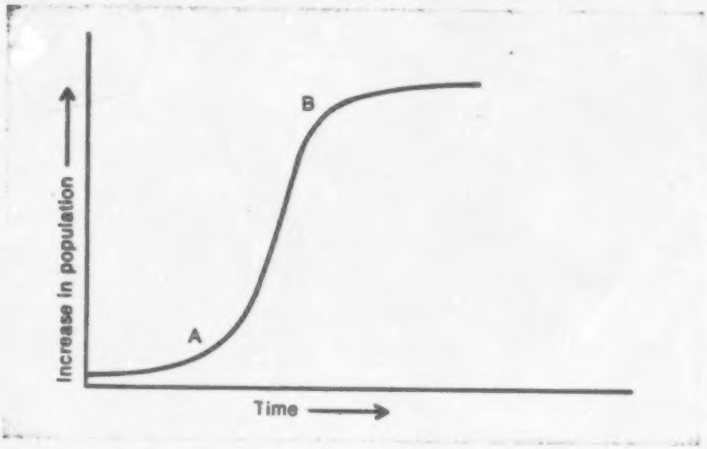


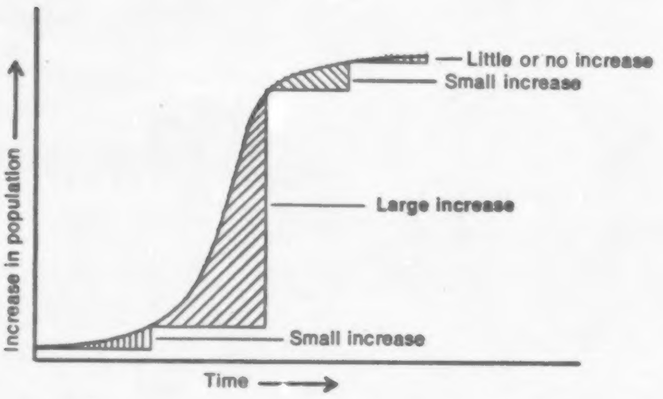
Figure 7-4

☐**7-8.** What happened to the size of the paramecium population up to point **A**?

☐**7-9.** What happened to the population during that part of the graph between points **A** and **B**?

☐**7-10.** What happened to the rate of population increase from point **B** on?

Figure 7-5



As you can see, there is first a small, then a great, increase in the population size. This sharp increase is followed by a leveling off in the rate of population change. Finally, the size of the population stays about the same. This is illustrated in Figure 7-5.

☐**7-11.** What variables would cause the population curve to level off after point **B**?

☐**7-12.** How does the curve in Figure 7-1 (the one for the human population change) differ from the typical population curve (Figure 7-4)?

In your answer to question 7-11, you may have suggested several variables that could limit the population level. Your list may have included some of the following:

1. The presence of disease organisms
2. The presence of wastes and poisons
3. Amount of food and needed gases
4. Availability of space for the organism

The environment cannot support more life than it can feed. Neither can it continue to support life if wastes and poisons become too concentrated. The greater the size of the population, the more the organisms are crowded together. Thus, accumulation of wastes increases.

Poor nutrition means a weakening of the living organism. Thus, chances of survival are reduced. Crowding and accumulation of wastes and poisons increase the likelihood of early death of the organism through spread of disease. Eventually, because of the input-output between environment and organisms:

Number of births in the population **EQUALS** Number of deaths in the population

EXCURSION

Excursion 7-1 describes an important experiment that was done to study population increase of mice. The excursion may give you an idea of how you might set up your own population study.

What then does all this mean for the human species? Man is an organism, and the population curves for organisms seem to have a similar shape. How much of the S-shaped population curve is complete for man? (Refer to your graph from Figure 7-1 in your Record Book.)

☐**7-13.** Does the rate of human population growth seem to be leveling off?

☐**7-14.** Does the total population predicted for the year 2000 suggest that there will be a leveling off of the curve by that time?

☐**7-15.** It is predicted that the 1970 world population will be doubled by the year 2007. Does your graph in Figure 7-1 support that prediction?

Apparently the curve in your graph is only a part of the typical population curve. The human population grew very slowly at first. Now it is growing rapidly. The question many people are asking is, "When will the human population level off?"

☐**7-16.** Give as many reasons as you can for why you think the world population can or cannot continue to increase indefinitely.

Scientists believe man is controlled by the same environmental factors that limit the populations of other living things. Overcrowding, famine (lack of food), and pollution perhaps are some of these factors.

Man's output has become the environment's input back to him. How will these inputs affect his numbers?

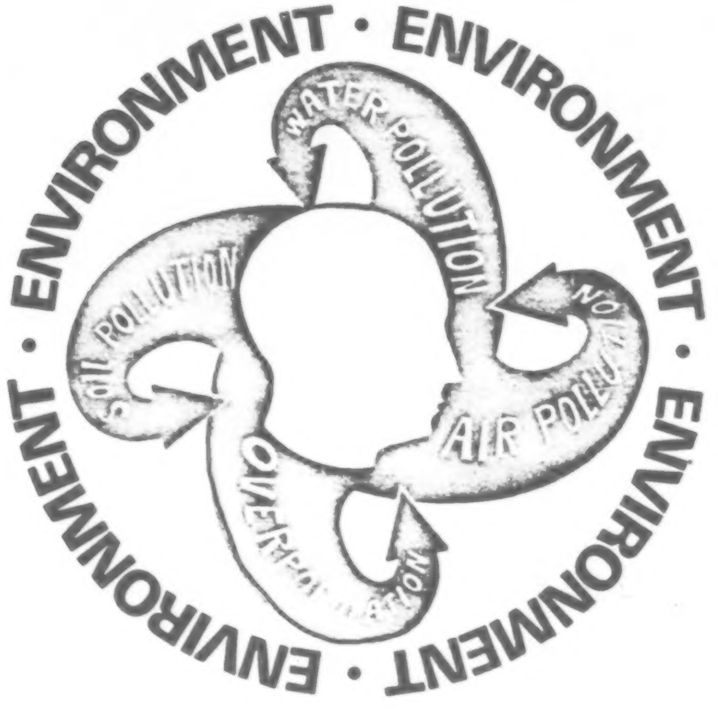
Some people believe man can escape an overpopulated planet before it is too late. If you are one of these, you'll want to look at **Excursion 7-2**, "Escape into Space."

◀**EXCURSION**

Some folks argue that there is only one way to stop overpopulation. **Excursion 7-3** illustrates their ideas.

◀**EXCURSION**

Before going on, do Self-Evaluation 7 in your Record Book.


ENVIRONMENT • ENVIRONMENT • ENVIRONMENT • ENVIRONMENT •
WATER POLLUTION
AIR POLLUTION
OVERPOPULATION
SOIL POLLUTION

95

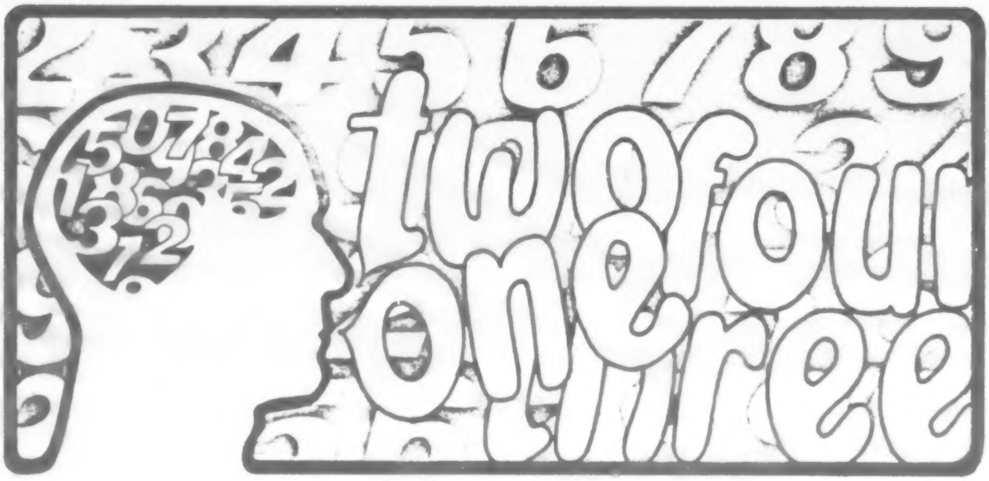
Facing Real Problems

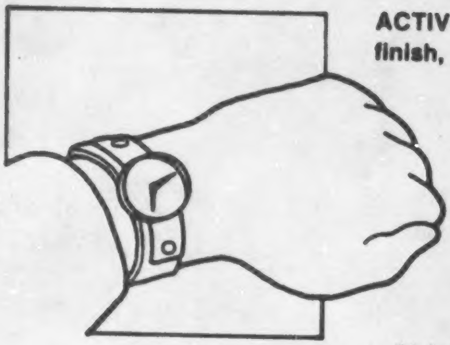
Chapter 8

For most of us, it is hard to believe the earth will ever be overcrowded. Four billion people—earth's present population—sounds like a lot, but can you imagine what such a number means? If you are like most people, numbers of that size don't mean much. Even the number 1,000,000 is more than most people can manage.

Perhaps the following activity will help you appreciate the size of the world population and the rate at which it is changing.

Suppose you had to count all the new people added to the world's population. You can find out how good you would be at this job by seeing how long it takes you to count a few people—all those in your classroom. You will need a watch or timer.





ACTIVITY 8-1. Note the time when you begin, and when you finish, counting all the people in the room.

Using the following formula to get your people-counting rate:

$$\text{People-counting rate} = \frac{\text{Number of people counted}}{\text{Time (seconds)}}$$

☐**8-1.** What is your people-counting rate?

Even though your rate may be faster, let's suppose you counted one person every second.

☐**8-2.** How many people could you count in one minute? in one hour?

☐**8-3.** Suppose you counted at that same rate for one day (24 hours). How many people would you have counted? (Sorry, no time out for meals, rest, or sleep.)

☐**8-4.** Suppose you worked 24 hours per day for the next year (365 days). How many people would you have counted by the end of the year?

☐**8-5.** Suppose you put in the next 59 years counting people at the same rate (24 hours per day with no breaks). How many people would you have counted at the end of 60 years?

After 60 hungry and thirsty years of hard work with no sleep, you could have counted less than two billion people. During that period, the world's population would have gone up by more than two billion. This means that you would have more people still to count than you started with.

To measure gains in population, you have to know more than just how many people are born. You also need to know how many die.

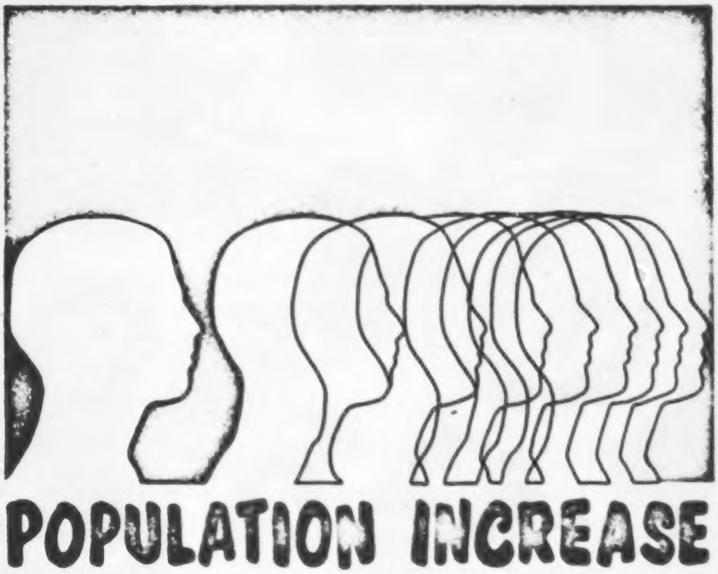
☐8-6. Complete Table 8-1 in your Record Book.

Table 8-1

WORLD POPULATION	
Birthrate	= 311,000 per day
Death rate	= 138,200 per day
Gain in population	= ______ per day

☐8-7. What is the daily gain in the world's population?

Apparently, people-counting isn't a very rewarding occupation. One person just can't keep up with the work. An even more impossible job would be trying to keep up with the needs (food, housing, schools, etc.) of so many people.



People living in cities and towns want such services as electricity, water, and telephones. They want to be able to buy food and drugs from local stores. They need airports, schools, hospitals, fire and police protection. They need jobs as a source of income.

You have seen that when people live close together, each person's output combines with that of others. The total output can produce serious pollution problems. You also know that the trend is for people to move to cities and to live closer and closer together. Thus, you can expect things to get worse in the future.

The rest of this chapter highlights some of the kinds of problems you may have to help solve when you get older. Try to examine each problem break from as many different viewpoints as possible.

In conducting your investigations and in proposing solutions, keep in mind that your plans will affect many other people. Also, be aware of what your plan will cost. Time is important, too. You should consider how long it will take to carry out your plan. Make use of all you have learned throughout this unit. Use other knowledge you have gained from reading, from television, and from radio. Discuss your ideas with your classmates and teacher.

PROBLEM BREAK 8-1

A strange insect that spreads a rustlike disease has suddenly attacked thousands of acres of crops in your area! The farmers want to use large-scale sprayings of insecticide to kill the insects, save their crops, and prevent further spread of the rust disease.

Other people are protesting the use of the insecticide. They are afraid that it will poison the soil and water for years to come. They are also afraid that the wind may carry the poisonous chemical into your town and onto nonfarming lands. To avoid these dangers, they suggest that the farmers burn their crops, thus killing the insects. Of course, the farmers' crops would be a total loss. And because the farmers borrow from the town's banks and buy in the town's stores, the townspeople would lose money, too.

What are the advantages and disadvantages of the two choices? What would you suggest as a solution?

VOTE
INDUSTRY

WITH SOME POLLUTION	WITH SOME POLLUTION
☐	☐
FOR	AGAINST

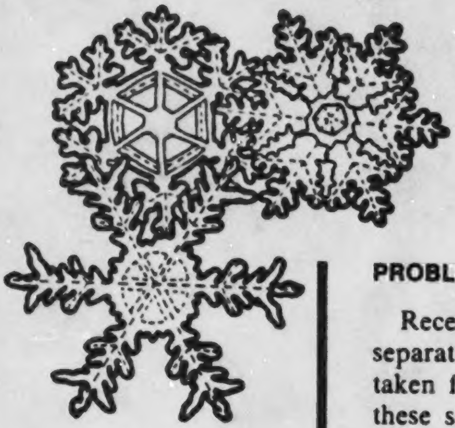
PROBLEM BREAK 8-2

The state of Noname has a small population. It has many farms but little industry. The amount of tax money the state gets is not enough to give each child a good education. Not much can be done for the poor or aged. Potholes fill the roads, more bridges need to be built, few fish and game animals are stocked, and state hospitals are such old firetraps that the governor wouldn't stay in one when he was sick.

A well-known electricity-producing industry has discovered a large deposit of hard coal. Unfortunately, the deposit lies in one of Noname's state recreation areas, beside the largest lake in the state. The industry feels it is an ideal place for a new power plant. The coal could be taken from the park by surface-mining and used as fuel. The cool, clean water from the swimming and boating lake could be used to operate steam turbines. The heated and polluted water would then be released back into the lake.

The industry agrees to sell to the state at a low price all the electricity produced. Tax money to the state would increase by 25 percent. Surrounding states could buy surplus electricity, bringing in more money. Furthermore, many other industries would soon move into the state because they could obtain cheap power.

What are the advantages and disadvantages of bringing in this industry? What limitations, if any, would you place on such an industry? Suppose Noname's state legislature must decide for or against the industry. As a state legislator, how would you vote? Why?



PROBLEM BREAK 8-3

Recently, samples of snow crystals were taken from widely separated areas of the United States. Some samples were taken from remote wilderness areas. Chemical analysis of these samples showed that lead particles were present in every region from which the samples were taken. It is believed the lead particles had been released to the air in automobile exhaust gases. The water in the clouds then formed ice crystals around the tiny lead particles.

Lead is a poisonous metal. It can accumulate in the bodies of living organisms and cause damage and even death.

As a member of the air-pollution control board of your state, what steps do you recommend be taken to control the release of this poisonous substance? What will be the effects of your suggested controls on the automobile industry? How will the citizenry be affected?

PROBLEM BREAK 8-4

Assume that the community in which you live is located on the seacoast. As the population increases, your town is faced with the problem of garbage and trash disposal. The city engineers and the townspeople disagree on how to dispose of the garbage. Several different proposals have been made to the city commission. They include the following:

1. Hauling the garbage out to sea and dumping it
2. Using trash and garbage to fill part of the bay and provide additional building sites
3. Using trash and garbage to fill low lands around the town and make them suitable for building sites
4. Compressing the trash and garbage into blocks and then covering them with concrete and using them as building materials

What position would you take on each of these suggestions and why? What alternative(s) would you suggest?

PROBLEM BREAK 8-5

The amount and variety of noise increases daily. High noise levels damage buildings as well as the human ear. Lower noise levels are sometimes irritating and may lead to an inability to think or sleep. Other effects of noise pollution are described in **Excursion 8-1**. You may want to take that excursion as you work in this problem break.

◀EXCURSION

Your city is likely to be as noisy as any other. Trucks, aircraft, motorcycles, and other noisemakers are bound to have their effects on your ears. As a community decision-maker,

1. what limits do you recommend be placed on noise sources?
2. what good and what bad effects would such limitations have?
3. should noise polluters be fined or punished just as air and water polluters are? If so, how?

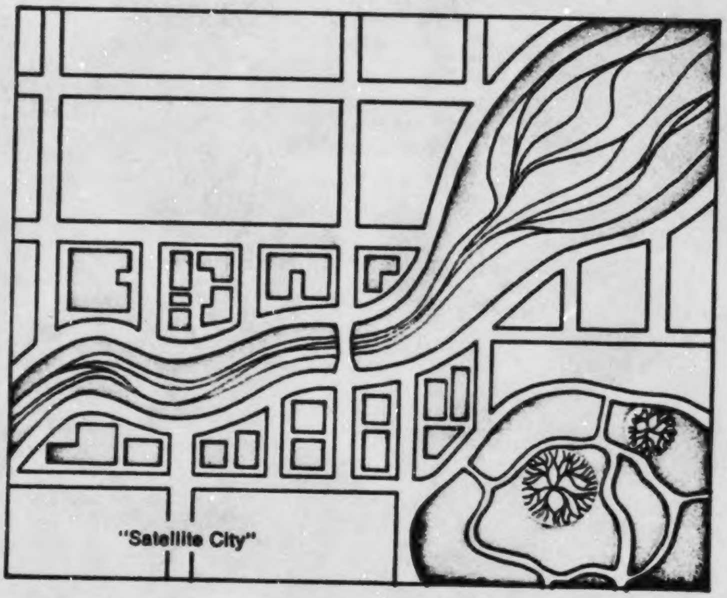
Every once in a while someone suggests that you can control the population of large cities by building new and smaller cities in less-populated parts of the country. They say that large industries could be invited to build factories in each new area, providing jobs for the new residents. Supporting businesses, such as groceries, utility companies, clothing goods, and so on, would move in to supply the needs of each new city. The planners would limit each new city to a certain size based on the predicted population increase. Of course, pollution control could start as soon as the first citizens arrived. Utopia?

PROBLEM BREAK 8-6

Suppose you are one of the planners for such a city. You are to help decide where it is to be located and what large industries to include. Setting up systems for water supply, sewage control, power, and transportation are all under the control of your planning group. Location of industries, businesses, schools, and so on, must also be decided by you and the other planners.

Talk with several classmates as you set up a study group for the planned community. If done correctly, this task will take much time and effort. Assume your city will start with 500 families. Permit a slow increase in new families during the next twenty years. Each family should average four members. Here are just a few of the problems you will face:

1. How will you select those who are to settle in your town?
2. From where will the city receive its food and water?
3. How will the people and industry be taxed?
4. What form of government will the city have?
5. What responsibility will your city have to the nearest neighboring towns?
6. What recreational facilities will be provided?
7. What will be the city's source of power?
8. How far ahead should you plan?



SAVE our PLANET

Hundreds of other questions could be listed. You will soon see that being a city planner is a tough job. Good luck to you and your group.

Your task won't be complete until you and your group have prepared a written plan. Be sure to include sketches of the proposed layout for the city. Don't forget to plan ahead!

The problem breaks you have completed contain a very important message. They point out that the solutions to environmental problems are far from simple. Understanding and dealing with pollution involve concepts in science, economics, politics, and sociology. Simple solutions to such difficult questions are very unlikely. Many points of view must be taken into consideration. And emotional reactions must give way to reason. Decisions must be based on the best information available.

Perhaps you, your classmates, and your teacher have thought of other environmental problems to investigate. You may wish to study problems that are currently being faced in your local area. Try tackling some of the kinds of difficult questions that are faced by the men and women who guide your community. It will help you understand the problems they face. It will also help prepare you to handle tough problems.

You have read and done a lot as you completed this unit on *Environmental Science*. You can consider that you have accomplished a lot if you

1. understand better the way the environment and living organisms interact.
2. see more clearly how living things depend on each other.
3. can identify causes of pollution.
4. know some of the effects of air, water, and soil pollution on living things.
5. realize that population increases require immediate, long-range planning to control man's effects on his environment.
6. recognize the difficult nature of the problems men and women face in providing a good life for their families.
7. can appreciate the importance of testing different ideas and viewpoints in seeking solutions to man's problems.
8. have learned that there are times to compromise and times to stand up for your ideas.

Before going on, do Self-Evaluation 8 in your Record Book.

Excursions

Do you like to take trips, to try something different, to see new things? Excursions can give you the chance. In many ways they resemble chapters. But chapters carry the main story line. Excursions are side trips. They may help you to go further, they may help you go into different material, or they may just be of interest to you. And some excursions are provided to help you understand difficult ideas.

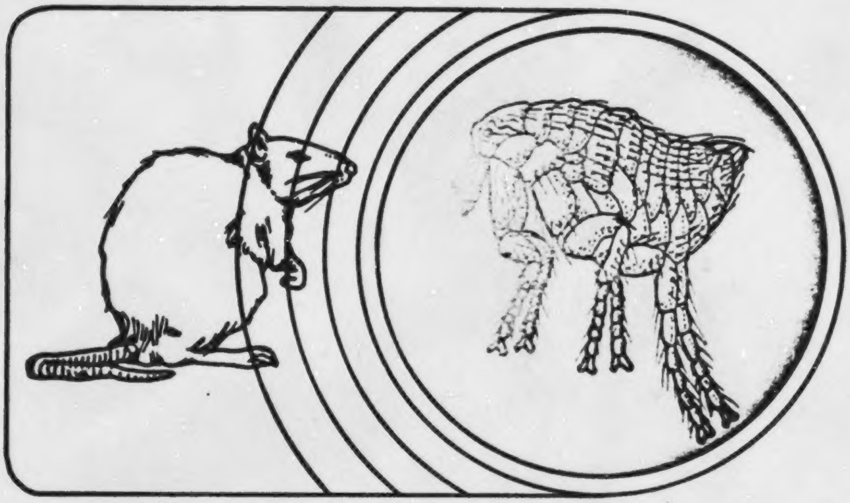
Whatever way you get there, after you finish an excursion, you should return to your place in the text material and continue with your work. These short trips can be interesting and different.

107

A Real Killer

Excursion 1-1

The Black Death, now called *bubonic plague,* is a disease spread by fleas infected with the bacteria *Pasteurella pestis.* The bite of an infected flea transfers the bacteria to the animal bitten. Because rats carry fleas, they help spread the disease from city to city and home to home. The rats themselves may become infected with the disease. The bacterial cause of the disease was not discovered until the 1890's—about five hundred years after the great plague of the 1300's. Even when the bacteria was discovered, it was not known for sure how it was spread. It is now known that the disease can be carried directly from person to person as well as by the flea.



In the 1300's, conditions in Europe were bad. Famine and overpopulation had produced poverty and overcrowded towns and cities. Raw sewage polluted the streets, and sanitary facilities were less efficient than those of Caesar's Rome. Cities were rat-infested, and people were ridden with fleas and lice. Conditions were ideal for the spread of a disease such as the plague.

In its journey across Europe, the plague took a great many lives. You can better appreciate the impact of this great crisis if you plot the data from Table 1 on the grid of Figure 1.

Table 1

Approximate Population (in millions)*	Year	Approximate Population (in millions)*	Year
56	1000	61	1450
58	1050	69	1500
61	1100	81	1550
64	1150	101	1600
68	1200	110	1630**
72	1250	100	1660**
79	1300	120	1700
83	1350		
60	1400		

**Estimated data; actual data unavailable.*

***Note that these figures are not for 50-year intervals.*

Some graphs don't start at zero. As you label your vertical scale on Figure 1, notice that you can label the bottom line "50" (for a population of 50 million). Every *horizontal* line can then stand for an increase of one million in the population. And your vertical scale can take care of a range from 50 million to 120 million people. Label only the lines that show an increase of 10 million population, and your scale won't become cluttered.

The horizontal scale shouldn't start at zero either. Label the left-hand vertical line "1000," and you should be able to complete the scale easily.

☐**1.** As you move to the right on the horizontal scale, what increase in years will you let each thin vertical line represent? each heavy vertical line represent?

☐**2.** Explain why you think it is, or is not, necessary to label on the horizontal scale every year that is listed in Table 1?

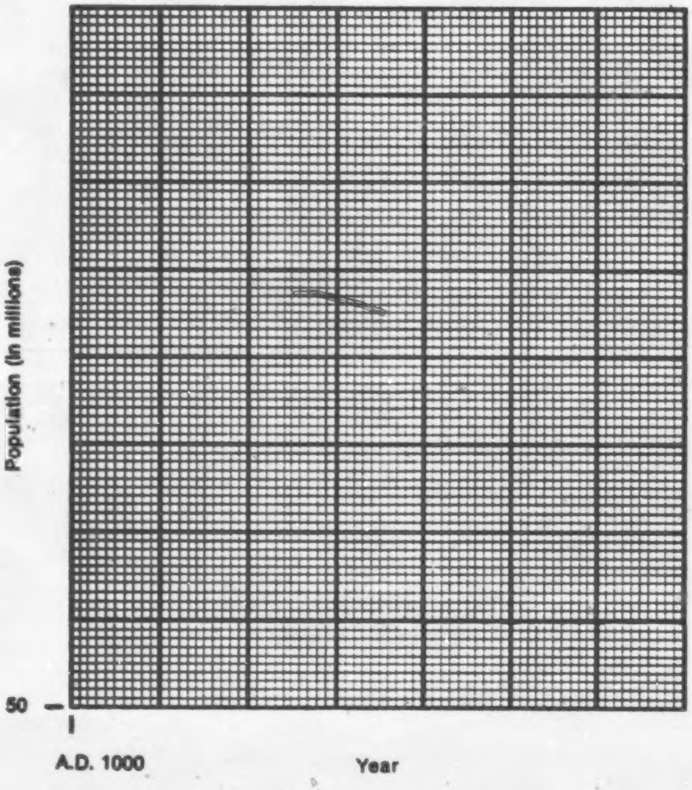


Figure 1

☐**3.** According to your graph, when did deaths from the plague occur at the fastest rate?

☐**4.** How many years passed before the population of Europe again rose to the pre-plague level?

☐**5.** What do you think might account for the dip in the graph during the 1600's?

☐**6.** How would you find out if your answer to question 5 is a good one?

Perhaps you would like to do some outside reading on the history of the bubonic plague. Here are a few references:

The Black Death. G. C. Coulton. Earnest Benn Ltd.

The Black Death: A Chronicle of the Plague. Compiled by Johannes Nohl. George Allen and Unwin Ltd.

The Bubonic Plague and England. Charles F. Mullett. University of Kentucky Press.

The Medieval Plague: The Black Death of the Ages. Geoffrey Marks. Doubleday & Company.

Plague and Pestilence in Literature and Art. Raymond Crawfurd. Oxford University Press.

Rearranging Particles Excursion 2-1

A particle model for matter was introduced in Volume 1 of ISCS, and developed in Volume 2. This model is based on scientific research. It is an attempt to explain the countless observations scientists have made of matter and its behavior. This scientific model attempts to account for the many similarities we see in the appearance and behavior of the substances that make up our world. The model also attempts to explain the differences we observe in substances.

It is impossible to provide all the arguments and reasons for each part of the particle model in the short space of this excursion. But it may be of help to list the different parts of the model, and then to explain a few of the more important ones.

1. All matter is composed of *particles.*
2. All matter is made up of one or more kinds of matter particles called *atoms.* There are 100 or so different kinds of atoms.
3. Substances composed of only one kind of atom are called *elements.*
4. During chemical changes, atoms undergo rearrangement. New substances formed during a chemical reaction are new combinations of the atoms that made up the original substances. These reactions may be accompanied by temperature changes.
5. When atoms combine, they do so in an orderly way. They are selective in combining. Atoms of one kind do not combine with every other kind of atom. When atoms do combine, a definite number of each is involved.

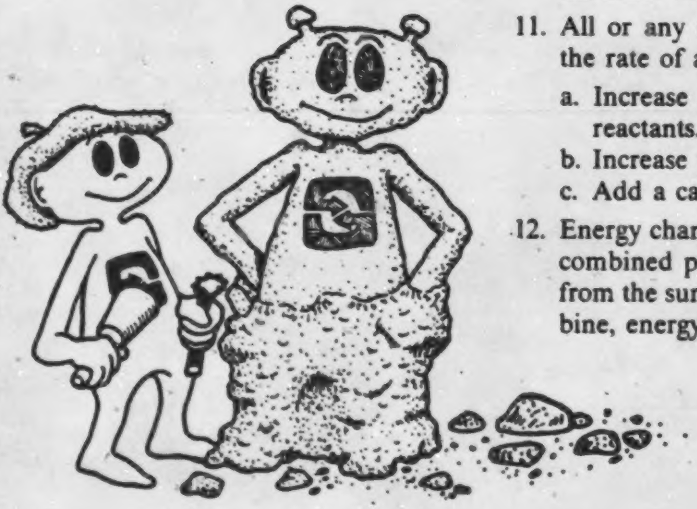
Answers to Checkup on page 8:

The following statements are correct and should have been marked with a check (√).

1. a,b,c
2. a,c,d
3. b,c

If you incorrectly marked more than one of the 11 choices for the three questions, you should complete this excursion before going ahead with Chapter 2. It will give you a quick review of the ISCS particle model and how it explains chemical change.

6. Substances composed of more than one kind of atom combined in definite numbers are called *compounds.*
7. All matter is composed of three kinds of particles containing charge.
    a. One kind of particle has either excess negative or excess positive charge. These particles are called *ions.*
    b. The other two kinds of particles contain an equal amount of both positive and negative charge. They are said to be neutral. These two kinds of particles are called *molecules* and *atoms.*
8. Electrical forces between opposite kinds of charge hold together atoms and molecules, as well as ions, to form elements and compounds.
9. Molecules are made of atoms. Large molecules can be broken up into smaller molecules and even into atoms. And smaller molecules can be combined to form larger molecules.
10. The neutral atoms in a molecule are held together by the force of attraction between opposite charges.
11. All or any of the following can be used to increase the rate of a chemical reaction.
    a. Increase the concentration of one or more of the reactants.
    b. Increase the temperature of the reactants.
    c. Add a catalyst to the reactants.
12. Energy changes accompany chemical reactions. When combined particles are separated, energy is absorbed from the surroundings. When separated particles combine, energy is released to the surroundings.



If you studied Volume 2 of ISCS, you may remember that the particle model for matter and its changes applied to both living and nonliving things. It proved useful in explaining the changes you observed when you studied living creatures such as fish and microscopic organisms.

Each part of the particle model is important. However, there are some parts of the model that need more emphasis. These ideas will help you understand more fully your study of environmental changes.

The model assumes that all substances in nature are made of invisible particles called atoms.

☐**1.** What name is given to substances containing only one kind of atom?

☐**2.** According to the model, how many substances are there that contain only one kind of atom?

☐**3.** What name is given to substances containing two or more different kinds of atoms?

☐**4.** Does the model suggest how many substances there are that contain two or more different kinds of atoms?

Because of certain forces resulting from electrical charge, atoms may be attracted to each other. As a result, the atoms form combinations. These combinations are what hold atoms together in elemental and compound substances. Figure 1 illustrates this.

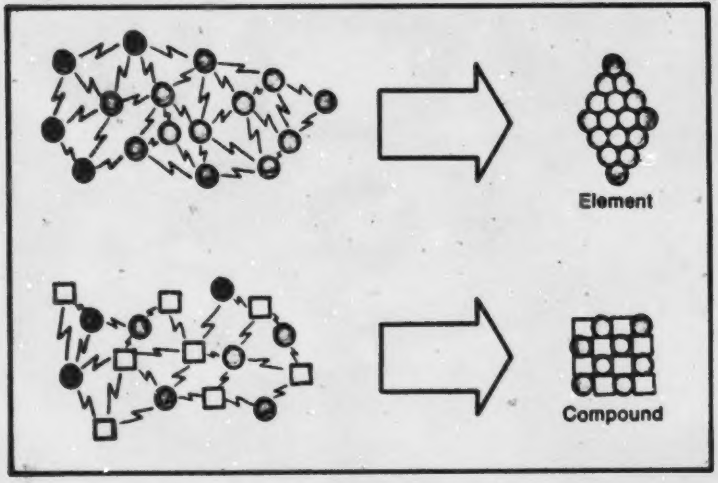
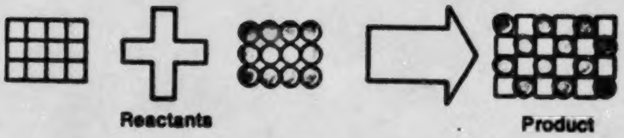


Figure 1

A chemical change is said to have occurred whenever any of the following take place:

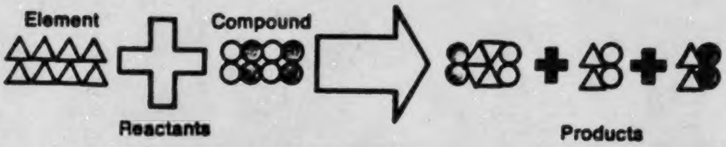
1. Atoms of one element combine with those of another element to form one or more new combinations.

Figure 2



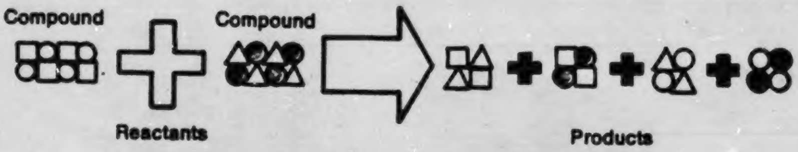
2. Atoms of one or more elements combine with atoms of one or more compounds to form one or more new combinations.

Figure 3



3. Atoms of two or more compounds combine to form one or more new combinations.

Figure 4



In each of the cases, the starting substances and their atoms are called *reactants.* The new substances produced are called *products.* The arrows indicate that products come from reactants.

The atoms in the products of chemical change are always the same as those in the starting reactants. This idea of atom conservation is very important. Check the illustrations in Figures 1 through 4 to see if the symbols show that atoms are conserved.

The particle model says that combined atoms are held together by forces of attraction. If reactants are to be changed to products, a very important thing must happen to the reactant atoms. They must be separated so that they can combine in new ways. Unless new combinations are formed, no new products result. To separate the combined reactant atoms, the forces of attraction between them must be overcome. Overcoming these forces requires an input of energy in some form.

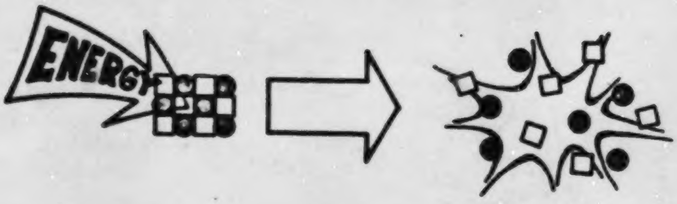
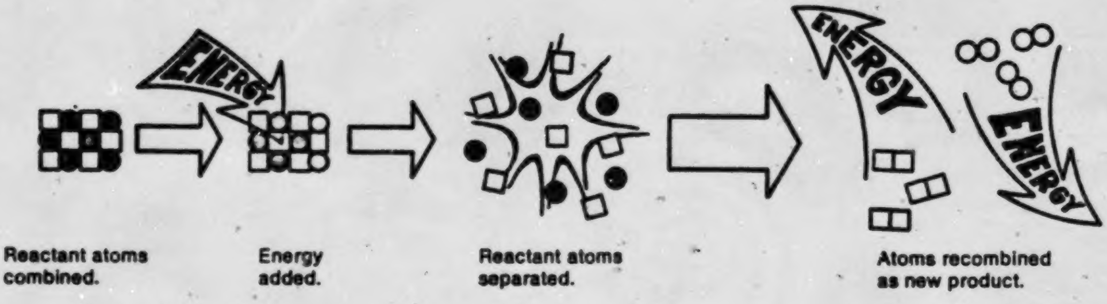


Figure 5

The energy needed to break up combinations of atoms can be in one of several forms. Heat, light, and electrical energy can all be used to separate combined atoms so that chemical changes can occur.

Once the reactants' atoms have been separated, they may then combine in new ways to form products. In terms of energy, these recombinations are the reverse of atom separation. The separating of atoms absorbs (takes in) energy. The combining of atoms releases energy. Figure 6 illustrates the total reaction process.

Figure 6


ENERGY
ENERGY
ENERGY
Reactant atoms combined.
Energy added.
Reactant atoms separated.
Atoms recombined as new product.

Temperature changes frequently occur as a result of a chemical change. These changes result from the absorption and release of heat by the reactants.

☐**5.** In which of the following reactions do you predict the temperature of the surroundings will increase? will decrease?

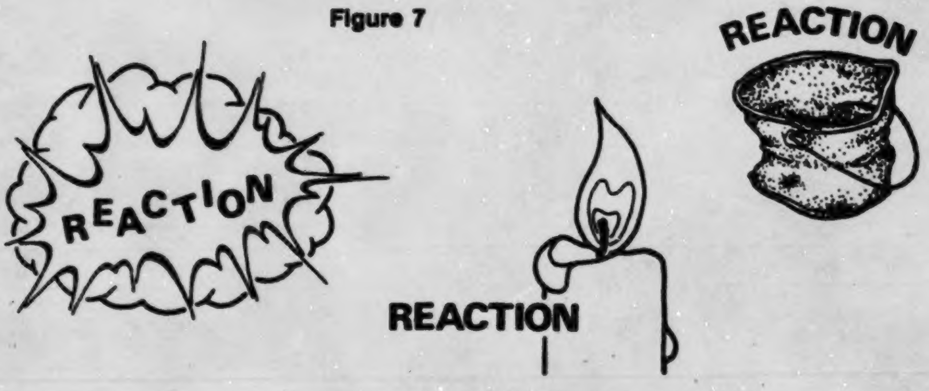
Reaction A: The heat needed to separate the reactant atoms is greater than the heat released when those atoms recombine to form products.

Reaction B: The heat needed to separate the reactant atoms is less than the heat released when those atoms recombine to form products.

☐6. Suppose a chemical reaction resulted in no change in the temperature of its surroundings. What would you predict about the energy absorbed and released by the reacting atoms?

You should be aware of another important characteristic of chemical reactions—their rate. The *rate* of a chemical change refers to how fast the reaction occurs. Some reactions occur so rapidly and violently that we refer to their rate as "explosive." Some reactions occur at a rapid but steady rate. And some reactions are very slow indeed.

Figure 7



Most of the chemical reactions you witness from day to day vary from slow to reasonably rapid. Very few are explosive. The slow and rapid reactions can be speeded up, however. There are three ways of doing this.

1. Increase the temperature of the reactants. (It is reasoned that increasing the temperature speeds up the addition of the energy needed to overcome the forces holding reactant atoms together.)
2. Increase the concentration of one or more of the reactants. (Increasing concentration is thought to bring more reactant atoms together faster, thus making reactions occur more quickly.)
3. Add a catalyst. (A catalyst is a chemical that, even in very small amounts, speeds up a reaction. The precise reasons for its effects are not known.)

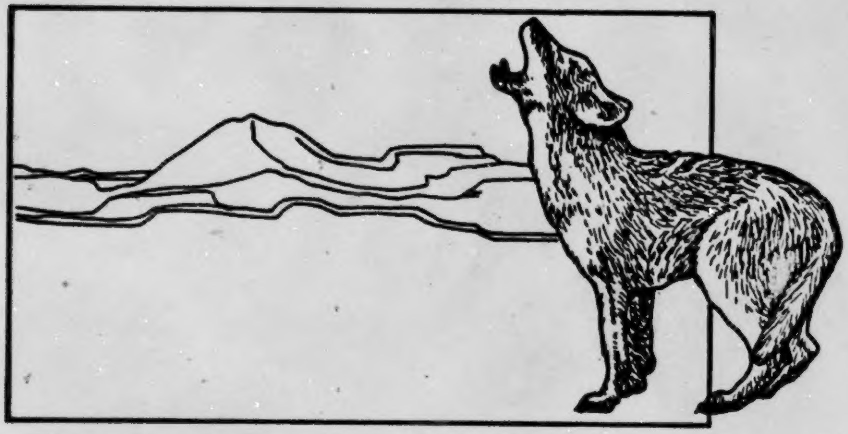
Items 1 and 2 will be the most important of the three to remember for your work in this unit.

Now return to your work in the chapter.

Bounty Hunters

Excursion 2-2

"Wanted—Dead or Alive." Such signs are to be found throughout the United States. However, they no longer apply to outlaws. Instead, they are aimed at certain animals that some men believe should be eliminated. These include such animals as wolves, coyotes, hawks, and mountain lions. Because these predators sometimes feed upon man's livestock, they have a "price on their head" in many states. Should these predators be killed? What happens when these animals are eliminated? This excursion will help you answer these questions.



The coyote is a common doglike animal that lives in parts of the region shown in Figure 1.

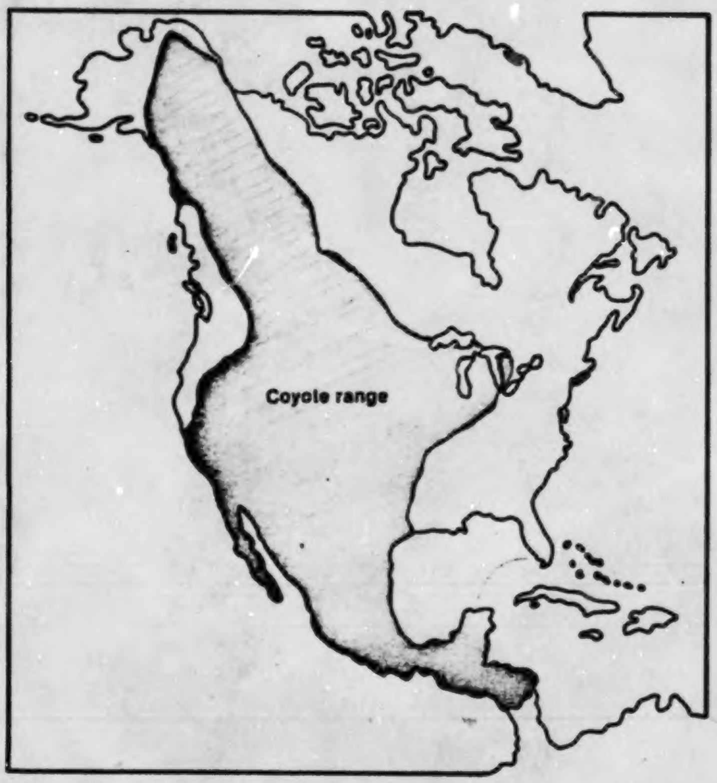


Figure 1

Once occupied by buffalo and sage hens, this region now supports cattle and chickens. The coyote and some other carnivores (meat eaters) have shifted their feeding habits to include the new domestic organisms. Farmers and ranchers claim that millions of dollars worth of livestock are destroyed annually by coyotes.

Supporters of the coyotes don't question the fact that they kill livestock. However, they suggest that the coyotes do more good than harm by eating large numbers of rodents. Because of this coyotes help keep the population of these smaller plant-eating animals under control.

When rabbits or rodents are common, coyotes may not eat all of every one they kill. When rabbits or rodents are scarce, however, coyotes usually consume all of each catch. It is estimated that a coyote eats about 125 cottontails and 15 jackrabbits a year. The coyote may indeed save grass for the rancher's animals, because each rabbit would otherwise be eating the grass that cattle or sheep might eat.

Some estimates comparing the amount of plant material eaten by rabbits, cows, and sheep are shown in Table 1.

	Number of Rabbits it Takes to Eat as Much as:	
	One cow	One sheep
Jackrabbits	75	15
Cottontails	250	50

Table 1

☐**1.** How many cows could be fed on the grass that each coyote saves when he eats his year's diet of cottontails? his year's diet of jackrabbits?

Suppose a region has a population of 25,000 coyotes and an ample supply of rabbits.

☐**2.** How many cottontails would 25,000 coyotes eat annually? How many jackrabbits?

☐**3.** How many additional sheep could graze on the grass saved by the coyote? (Assume only sheep are raised in the region.)

☐**4.** If only cattle were raised in the region, how many additional cows could be fed by the grass saved by the coyotes?

Coyotes do a good job of controlling the population of rabbits and rodents. Without the coyote, these populations would be likely to increase at a high rate.

☐**5.** How would such an increase affect the amount of grazing land needed to nourish a cow?

☐6. Suppose it costs about $25 per cow each year to provide grazing. How much money could 25,000 coyotes save ranchers each year for the cattle in the region being studied?

Of course, this is only part of the story. If rabbit and rodent populations are very small, a coyote may eat chickens and an occasional calf or sheep. They may also eat insects, berries, prickly pears, and even mud!

☐7. Write in your Record Book your conclusions concerning the good and bad points of coyote control.

☐8. What additional information would you like to have before you can decide whether bounties should be paid for dead coyotes or whether it should be made illegal to kill coyotes?

A Drink of the Nile

Excursion 3-1

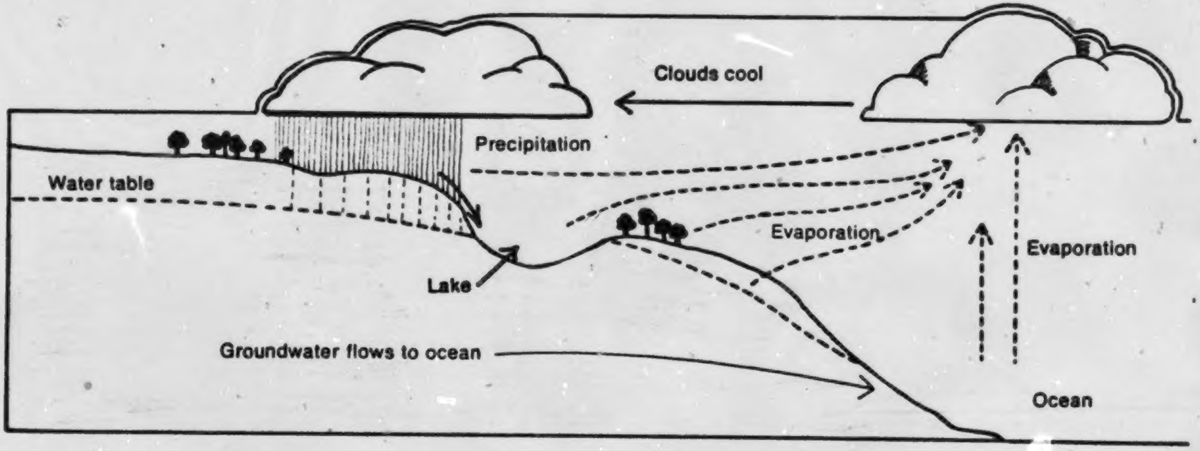
Some of the water in your last drink may once have been part of the Nile River. As impossible as it may sound at first, it makes sense when you look at the never-ending movement of water. Figure 1 shows the so-called water cycle. The important thing to observe is that the water is used over and over again.

Notice that water falls to earth as precipitation (rain, snow, sleet, hail, etc.).

☐**1.** Once having fallen to earth, where might water go?

☐**2.** How does surface water get back into the air?

Figure 1


Clouds cool
Precipitation
Water table
Evaporation
Evaporation
Lake
Groundwater flows to ocean
Ocean

Look closely at Figure 2 and you will see that precipitation does not occur evenly in the United States.

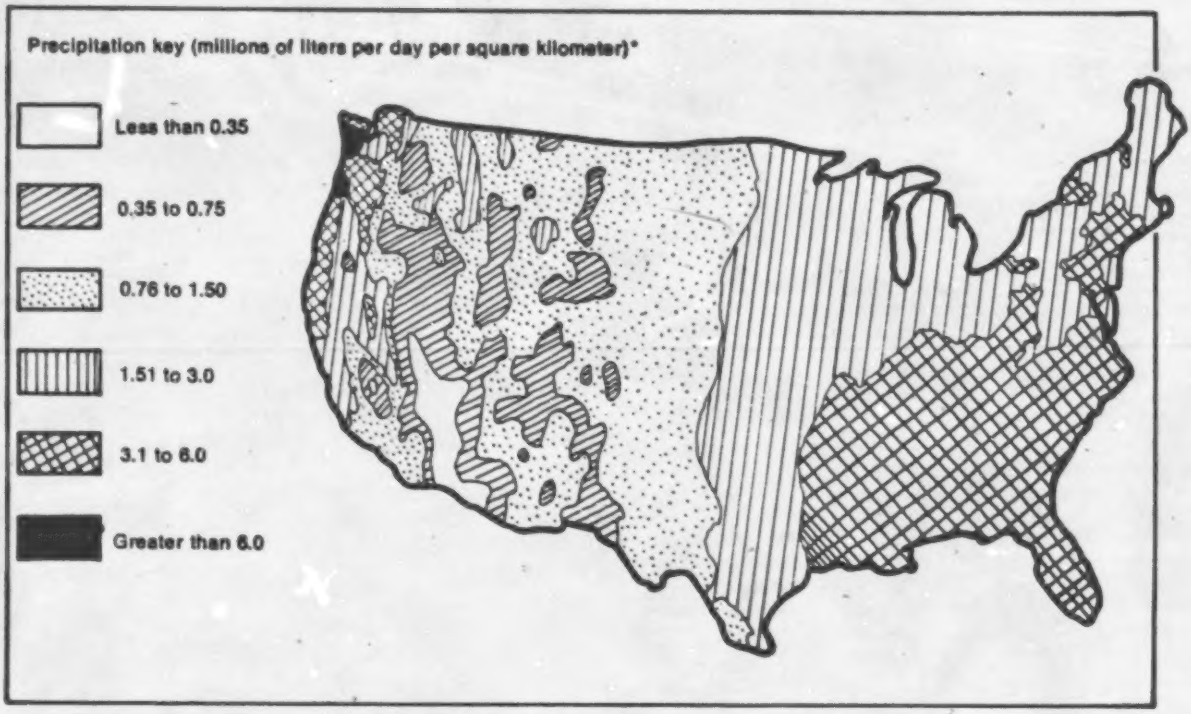

Precipitation key (millions of liters per day per square kilometer)*
Less than 0.35
0.35 to 0.75
0.76 to 1.50
1.51 to 3.0
3.1 to 6.0
Greater than 6.0

Figure 2

☐**3.** According to Figure 2, what is the approximate average precipitation where you live?

☐**4.** What sections of the country receive the greatest precipitation?

☐**5.** What sections of the country receive the least precipitation?

☐**6.** How do you explain the large differences in precipitation?

The amount of precipitation is not the only factor that affects the amount of water available in a given region of the country. Climate, soil types, amount of runoff into the sea, and population also have their effects. As a result, some areas have a surplus of water, while others have a water deficiency. The effect of humans on the supply of water is a serious one.

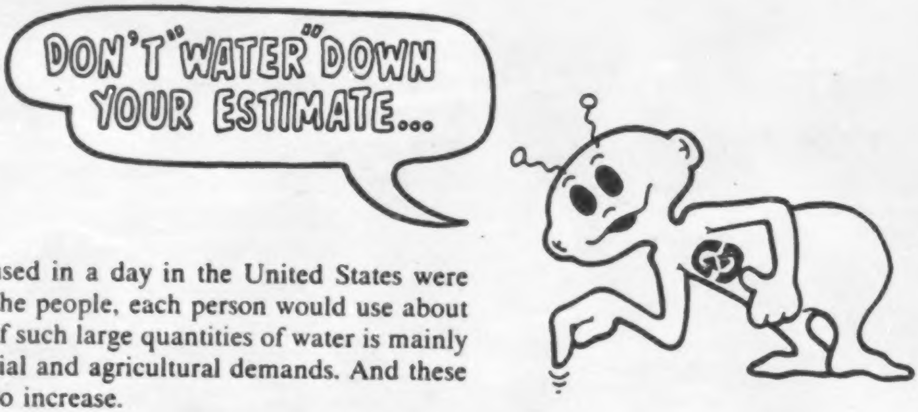
Just how much water do people use daily? Table 1 shows the average amount of water used in some everyday activities.

Table 1

AVERAGE DOMESTIC (HOME) WATER USE IN THE UNITED STATES

Purpose	Amount (liters per person per day)
Flushing toilets	78
Washing and bathing	70
Kitchen use	11
Drinking water	10
Laundry	8
General household cleansing	6
Gardening	6
Washing the car	2

☐**7.** How much water do you estimate that you use daily?


DON'T "WATER" DOWN YOUR ESTIMATE...

If all the water used in a day in the United States were divided up among the people, each person would use about 575 liters. The use of such large quantities of water is mainly the result of industrial and agricultural demands. And these demands continue to increase.

☐**8.** What is the total average daily domestic water use in the United States? (Assume a U.S. population of 210,000,000.)

Table 2 shows how the demand for water has increased in the United States this century.

Table 2

AVERAGE DAILY WATER USE IN THE UNITED STATES

	Type of Use (billion liters per day)			
Year	Domestic	Agriculture	Industry and Steam Electric Utilities	Total Water Use
1900	19	76	57	152
1920	32	212	103	347
1940	50	269	198	517
1960	106	510	605	1,221
1980*	127	673	1,046	1,846

**Estimated*

☐**9.** According to the data in Table 2, what trend is evident in water usage?

☐**10.** What activity used the most water in 1900? in 1960?

☐**11.** Which category in Table 2 has increased its demand for water the most?

Today almost twice as many people live in the United States as did in 1920.

☐**12.** How does the increase in water use relate to the increase in population during this century?

The demand for water will certainly continue to increase. This increasing need raises many serious questions. Will there be enough water available to supply a growing population? What can be done to conserve our present water supplies? How can we find new ones? Can water be redistributed so that it is available where most of the people live? Will it be possible to desalt ocean water cheaply? Can polluted water be made usable again? These are just a few of the questions that you and your classmates will face and pehaps help to answer during your lifetime.

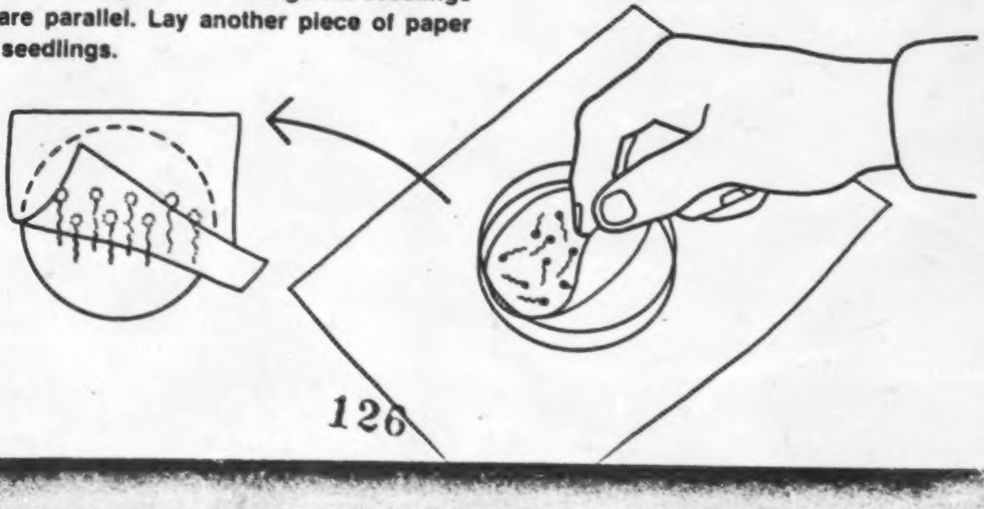
Clean Vegetables?

Excursion 4-1

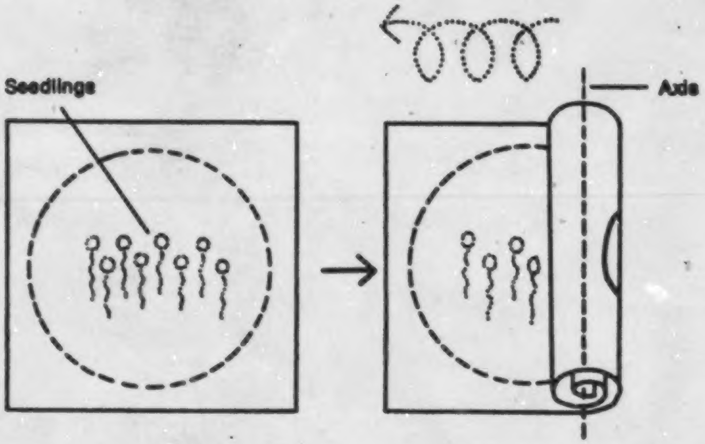
Suppose you planted some healthy seedlings in soil. And suppose you watered them with water containing detergents. What effect do you think this treatment would have on the growth of the plants? This excursion will help you answer this question. You will need the materials listed below. (Your teacher may allow you to take your materials home for this investigation. If so, take only those items you know you don't already have at home. If you do your work at school, skip Activity 2. Remember to water and observe your plants each day during the weekends.)

- 20 radish seeds (or all of those that germinated in the control dish from Chapter 4)
- Soil mixture (Obtain as needed.)
- 1 hand lens
- 1 millimeter ruler
- 2 one-quart milk cartons or bottles
- 5 level teaspoons of powdered or liquid detergent
- 3 planting containers (cans, halves of milk cartons, or styrofoam cups)
- 2 paper towels
- 1 rubber band

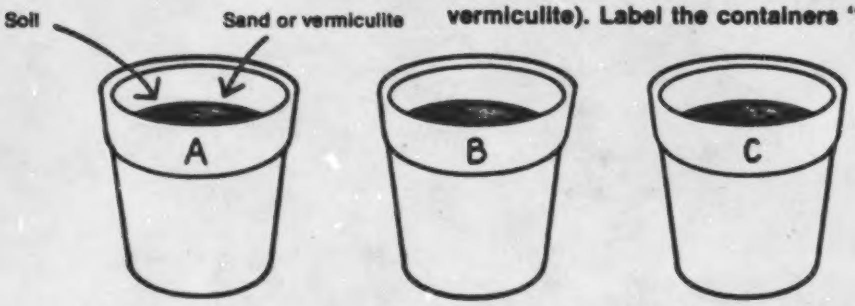
ACTIVITY 1. Remove the filter paper and seedlings from the two control petri dishes of Chapter 4. Rearrange the seedlings so that their roots are parallel. Lay another piece of paper towel on top of the seedlings.



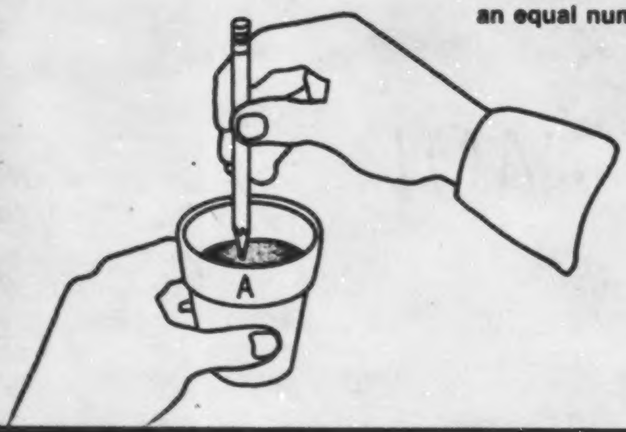
ACTIVITY 2. Gently roll the paper into a cylinder. To prevent breakage, be sure the cylinder axis is parallel to the seedling roots. Wrap another paper towel around the cylinder, and secure it with a rubber band. Your seedlings will now be protected for their trip home.

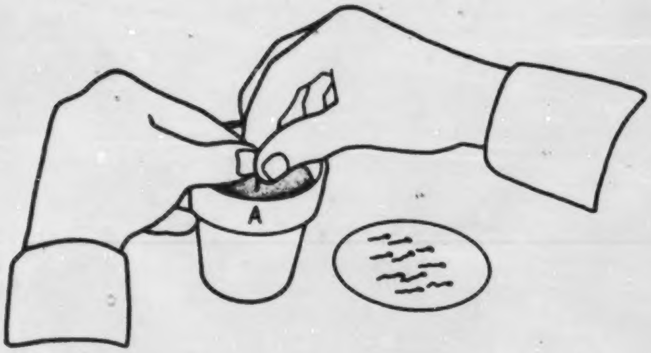


ACTIVITY 3. Fill three containers (cans, cartons, or cups) about 3/4 full of soil mixture (soil and sand, or soil and vermiculite). Label the containers "A," "B," and "C."



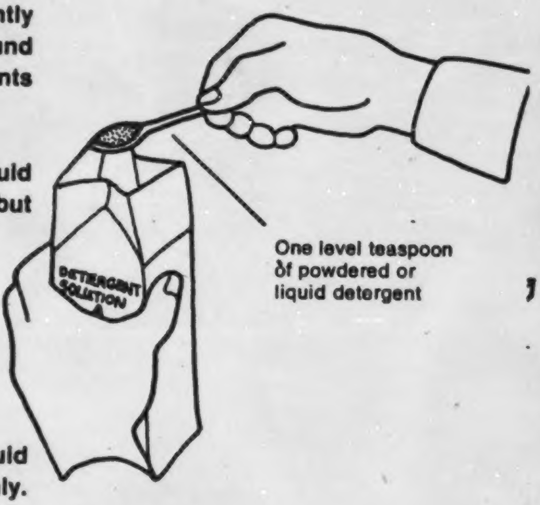
ACTIVITY 4. Punch holes in the soil with a pencil, making an equal number (about 6) in each container.





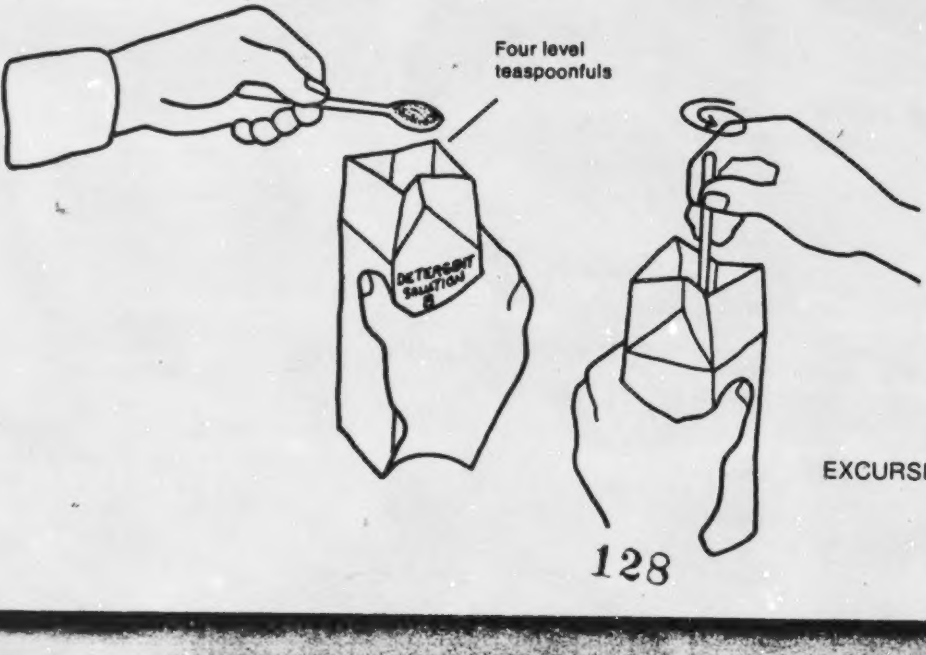
ACTIVITY 5. Plant one seedling at a time. Place it root downward in the hole and push dirt in around it. Do this gently so as not to damage the root. Gently press the dirt around the root. Repeat this procedure for each plant. Plant 6 plants in each container.

ACTIVITY 6. Put one level teaspoon of powdered or liquid detergent into a quart of water. Stir the solution gently but thoroughly. Label the container "Detergent Solution A."



One level teaspoon of powdered or liquid detergent

ACTIVITY 7. Put four level teaspoons of powdered or liquid detergent into the second quart of water. Mix thoroughly. Label the container "Detergent Solution B."



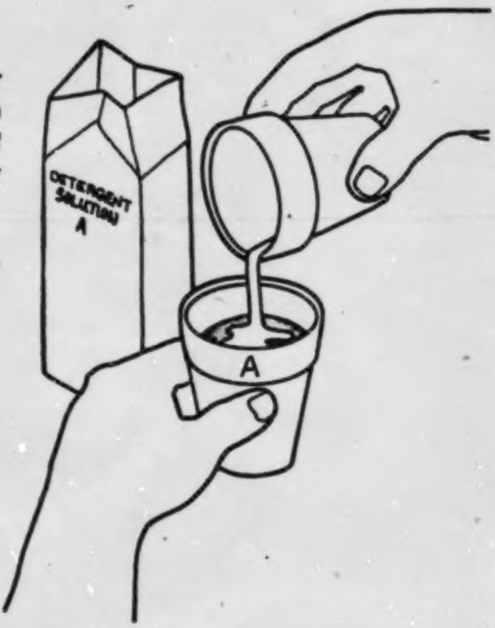
Four level teaspoonfuls

You are now ready to begin your investigation. You should plan to water the plants each day for several days. Follow the instructions in the next two activities. Keep the plants in a well-lighted place but not in direct sunlight. Be sure all get the same amount of light and heat.

You will need to determine your own method of measuring the growth of the seedlings. One measure can be of the plant's height. Record in Table 1 the average height for the group of seedlings in each container. Do this each day for 7 days. You can also check the root growth to see how the plant is doing.

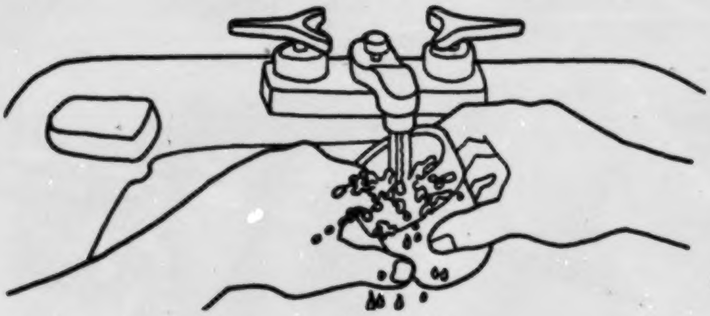
Table 1

		Average Height of Seedlings	General Conditon of Roots	Additional Observations
1 day after planting	Container A			
	Container B			
	Container C			
2 days after planting	Container A			
	Container B			
	Container C			
3 days after planting	Container A			
	Container B			
	Container C			
4 days after planting	Container A			
	Container B			
	Container C			
5 days after planting	Container A			
	Container B			
	Container C			
6 days after planting	Container A			
	Container B			
	Container C			
7 days after planting	Container A			
	Container B			
	Container C			

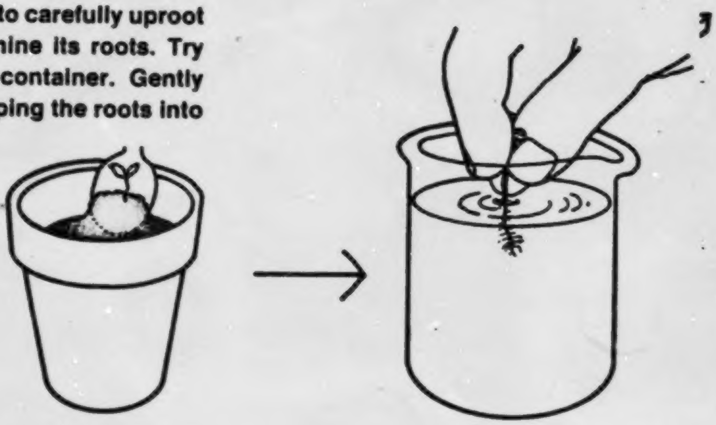


ACTIVITY 8. Each day, after making your observations, water the plants. Plants in container A receive enough of solution A to soak the soil. Those in B receive the same amount of solution B. The plants should not be standing in water. Pour off any excess.

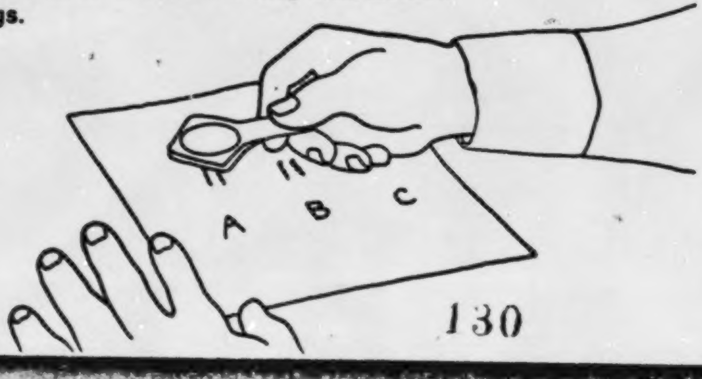
ACTIVITY 9. Rinse the glass before adding enough tap water to container C to soak the soil.



ACTIVITY 10. On the third day, use a spoon to carefully uproot one seedling from each container to examine its roots. Try to select the healthiest plant from each container. Gently remove any soil clinging to the roots by dipping the roots into water.



ACTIVITY 11. Lay the uprooted seedlings on a labeled sheet of paper. Examine them closely with a hand lens. Compare the roots and describe them in Table 1. You may then discard the uprooted seedlings.



Repeat Activities 10 and 11 after two more days, and again after two additional days, uprooting one more seedling from each container each time. Record the results in Table 1.

☐**1.** How do different concentrations of detergent affect the plant development? (Record your conclusions about the investigation in your Record Book.)

☐**2.** In what way, if any, does your investigation suggest you should change your answer to question 4-6 in Chapter 4?

☐**3.** Do you predict that the detergent solutions would have the same effect on other seedlings? Explain your answer.

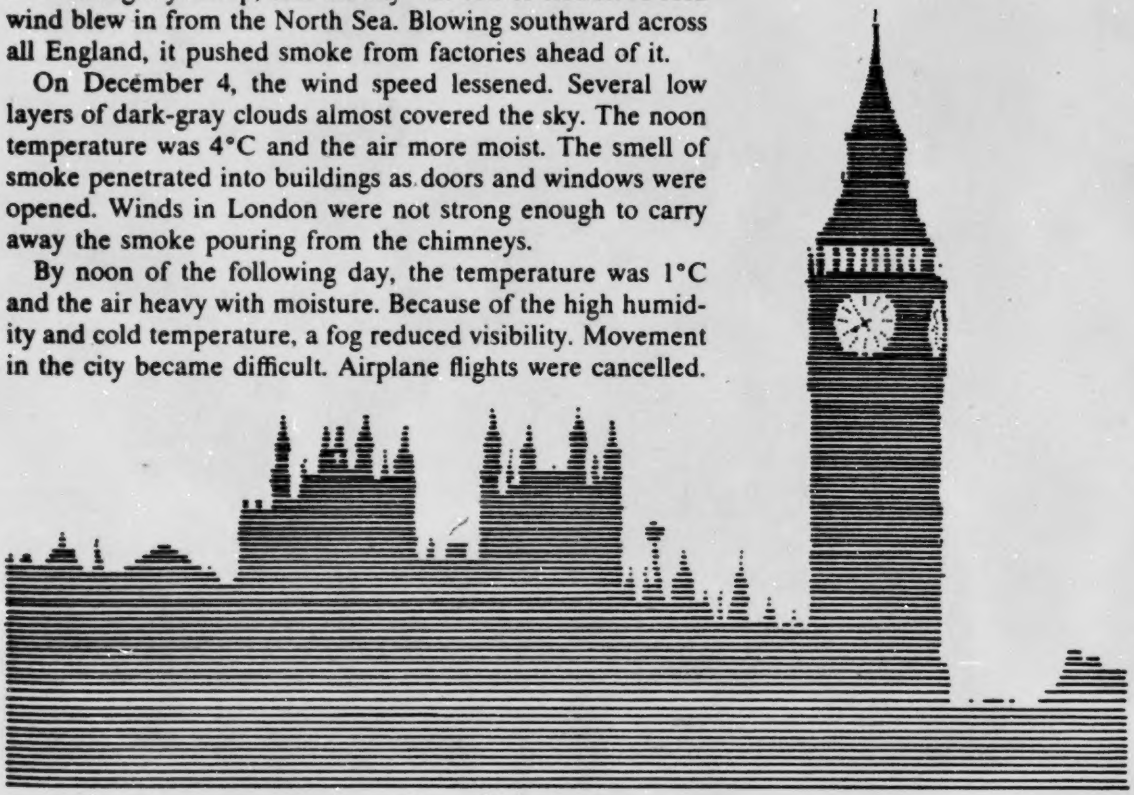
RADISH
SEEDS

Smoggy London Town Excursion 6-1

December 3, 1952, was a beautiful clear day in London. The weather forecasters reported that a cold front had passed during the night. At noon, the temperature reached 6°C. The air was slightly damp, and the sky was full of clouds. A cold wind blew in from the North Sea. Blowing southward across all England, it pushed smoke from factories ahead of it.

On December 4, the wind speed lessened. Several low layers of dark-gray clouds almost covered the sky. The noon temperature was 4°C and the air more moist. The smell of smoke penetrated into buildings as doors and windows were opened. Winds in London were not strong enough to carry away the smoke pouring from the chimneys.

By noon of the following day, the temperature was 1°C and the air heavy with moisture. Because of the high humidity and cold temperature, a fog reduced visibility. Movement in the city became difficult. Airplane flights were cancelled.



Very few people tried to drive. Even walking was hazardous. The wet, quiet fog that covered the countryside was loaded with smoke and soot particles. London was the captive of a great *smog*—a mixture of smoke and fog. These conditions existed from December 5 to December 9.

There was no escaping the polluted air. It crept into every room. It irritated eyes and skin, and brought on severe coughing for thousands. Hospitals were jammed with people. During the five days of the fog and in the week following, about 4,000 more people than usual died from lung conditions worsened by the smog.

On December 9, fresh air began blowing in from the south. On December 10, the smog was pushed away by a breeze coming from the north Atlantic.

The smog crisis in London in 1952 is an extreme example of similar conditions that now exist almost daily in many large cities and industrial towns of the United States.

These air-pollution conditions result from a combination of weather conditions and man's output of pollutants into the atmosphere. But how does this combination take place? Perhaps you know some of the answers already.

Table 1 provides data on air temperature taken by a weather balloon at different altitudes. Use the grid in Figure 1 in your Record Book to graph the data from the table.

Table 1

Altitude (meters)	Temperature (°C)	Altitude (meters)	Temperature (°C)
150	25	1200	5
300	23	1350	2
450	21	1500	0
600	20	1650	−3
750	16	1800	−5
900	11	1950	−9
1050	9	2100	−12

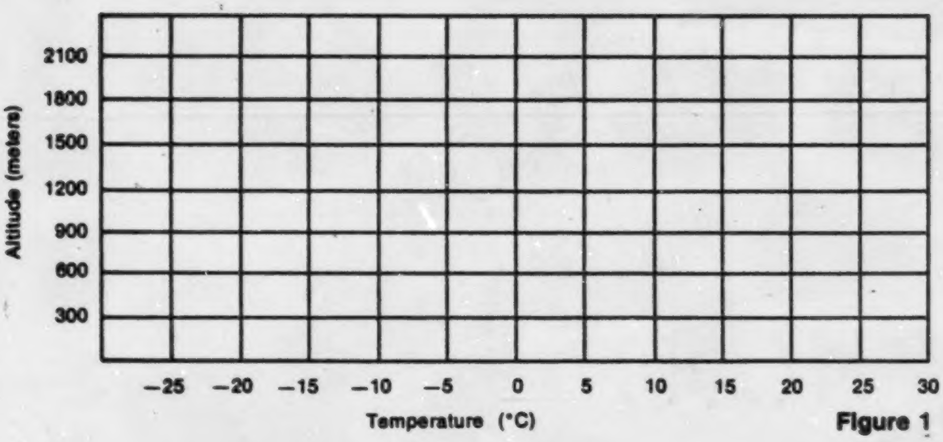
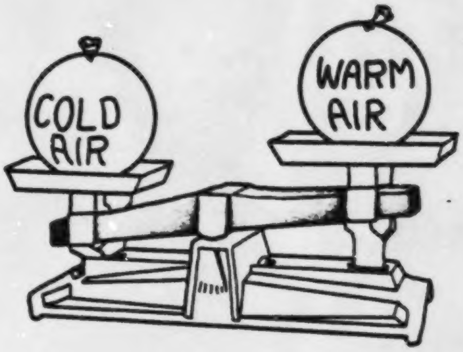


Figure 1

☐**1.** What relationship between altitude and temperature is shown by the graph of the data from Table 1?

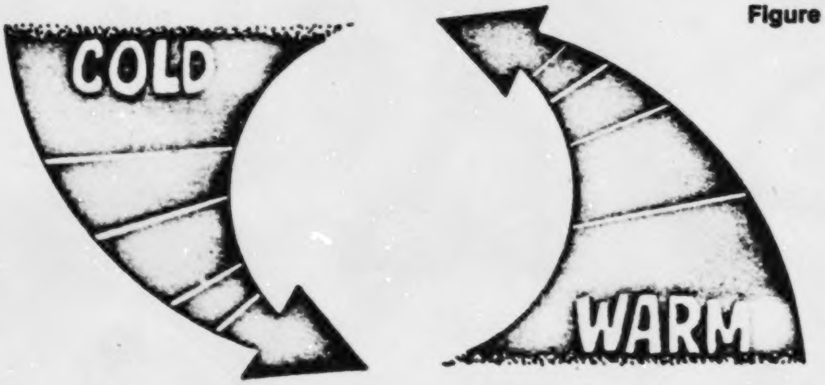


Frequently, the temperature of air at the surface of the earth is warmer than the air high above the earth.

You may know already that warm air is less dense than cold air. Because of this, warm air is forced upward. Or to say it another way: the mass of a volume of warm air is less than the mass of the same volume of cooler air.

Because it is denser than warm air, cold air falls toward the earth. This pushes the warmer air up. Under these conditions, the vertical (up-and-down) mixing of the air keeps the atmosphere stirred up. When smoke and other pollutants are poured into the air, they rise on these air currents to a distance far above normal breathing heights.

Figure 2



Why did the pollutants in the London air stay near the ground for those five days? Something must have stopped the vertical air motions just described. Let's see what the different conditions were like.

From the description at the beginning of this excursion (you may want to read that part again) you learned that the first weather change in the London crisis was the advance of a mass of cold air over the city. This is called a *cold front.* Figure 3 illustrates what normally happens when colder air moves into a region of warm air. Warm air is lifted up and over the colder air.

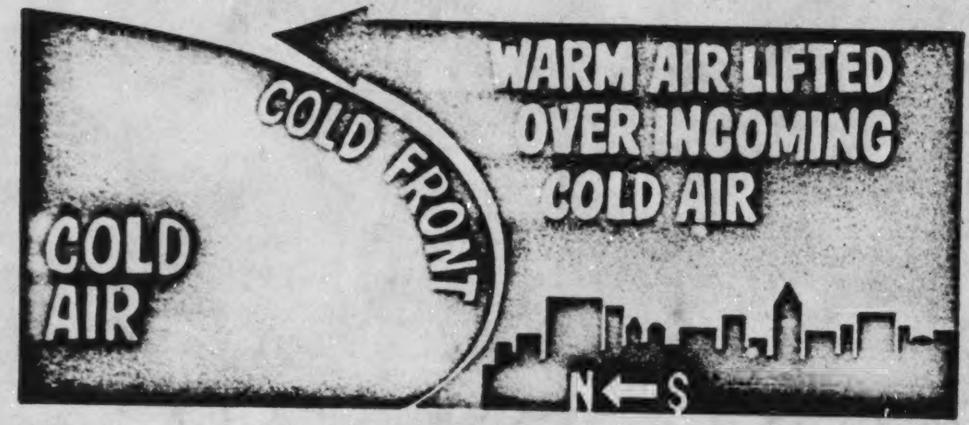


Figure 3

☐**2.** Why does the advancing colder air lift the warmer air?

When a cold front moves into an area, the dense cold air pushes the less dense warm air upward. Soon a cold air mass lies beneath a warm one. This condition is called a *temperature inversion.* Instead of decreasing with altitude, the temperature of the air first decreases, then increases, with increasing height above the earth.

Table 2 contains temperatures like those you would find in a temperature inversion after a cold front has passed through.

Graph the data in Table 2 on the grid of Figure 1 of your Record Book, alongside your first graph.

☐**3.** How is this new graph different from the first one?

A distinct layering of air occurs, with the coldest air nearest the ground. See Figure 4.

Altitude (meters)	Temperature (°C)	Altitude (meters)	Temperature (°C)
150	15	1200	0
300	13	1350	−2
450	11	1500	−5
600	9	1650	−4
750	7	1800	−2
900	5	1950	1
1050	3	2100	4

Table 2

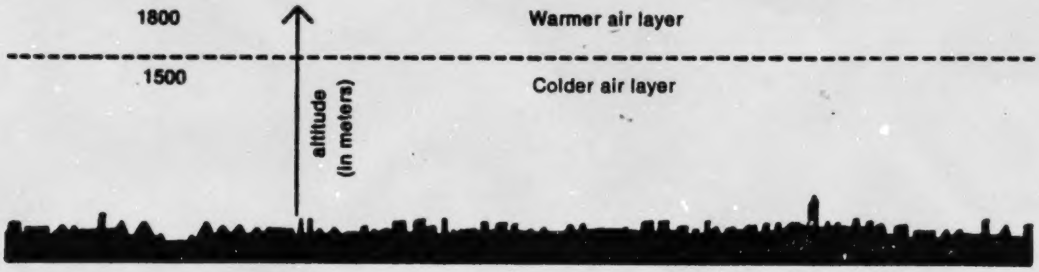


Figure 4

☐**4.** Predict how vertical mixing of the air would affect the layering of the air.

☐**5.** Suppose no wind is blowing during a temperature inversion. This means the air will be almost motionless. Where are smoke and other air pollutants likely to collect during a temperature inversion?

When the cold front passed over London in early December 1952, it produced a temperature inversion that prevented vertical air mixing. Since there was no wind to blow the pollutants away, they remained in the colder air layer near the earth's surface. Thus, the pollutants began to collect in the breathing space of man.

☐**6.** Assume that you are the Smog Control Director for London. Would you recommend that the thousands of factory furnaces be shut down whenever a cold front approaches? Why?

☐**7.** Would you recommend that all motor vehicle traffic be prohibited whenever a cold front approaches? Why?

☐**8.** Would you recommend that artificial breezes be created over the entire city whenever the wind speed dropped to a near zero level? Why?

☐**9.** Would you force London industry to remove solid pollutants from chimney gases before releasing the smoke into the air? Why?

☐**10.** Would you recommend that all home furnaces be turned off whenever an air-pollution crisis occurs? Why?

Discuss your answers to questions 6 through 10 with other members of your class.

You've seen that a cold front can lead to a temperature inversion. Is this the only way a temperature inversion can occur?

Figure 5 shows what happens when a *warm front* moves into an area. Notice that as warmer air moves into a region of colder air, the leading edge of the front is forced upward.

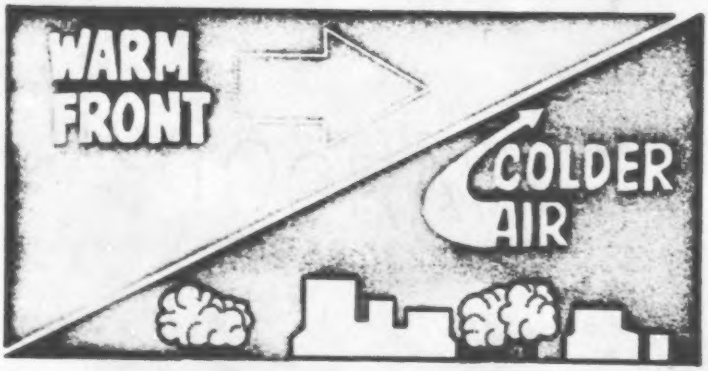


Figure 5

☐**11.** How can a warm front lead to a temperature inversion?

☐**12.** Would you predict that smog conditions would be worse as a result of a cold front, or of a warm front?

☐**13.** Which type of front condition would be most likely to result in a temperature inversion in your own area?

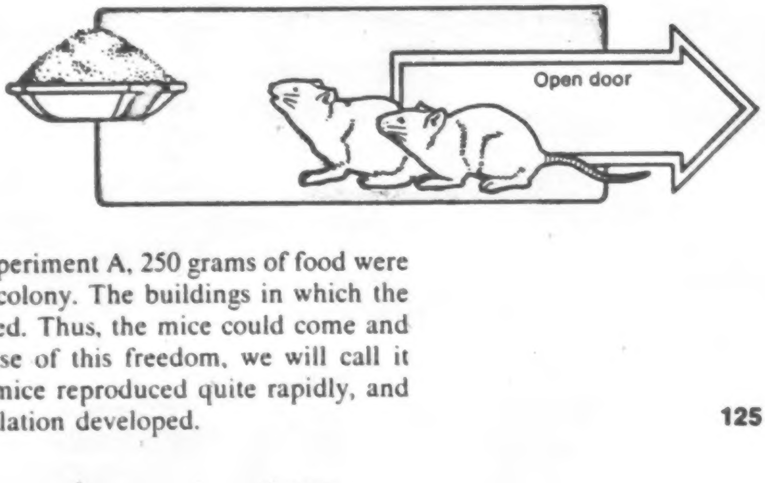
☐**14.** Why are smog conditions less frequent in farming regions than in industrial centers?

The More the Merrier? Excursion 7-1

What happens to people when they live in crowded conditions? There are at least two ways of tackling that question. One way is observing people in overcrowded conditions. The other is experimenting with a simpler animal. One *may* get hints of things to expect in the behavior of crowded humans, by observing overcrowding in animals.

Mice are common laboratory animals. In this excursion, you will learn about some experiments on crowding mice. Perhaps the results of the experiments will suggest something about how people react to overcrowding.

A famous population study was done by Dr. John Emlen at the University of Wisconsin. Dr. Emlen studied a colony of mice that lived in some old buildings. He conducted three experiments (here called A, B, and C). As you read about each of these, judge whether or not good controls were used.



Experiment A

During each day of Experiment A, 250 grams of food were provided for the mouse colony. The buildings in which the mice lived were not sealed. Thus, the mice could come and go as they chose. Because of this freedom, we will call it an "open system." The mice reproduced quite rapidly, and a larger and larger population developed.

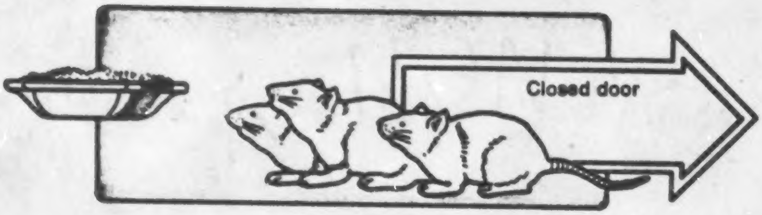
For a time, all these "open system" mice remained in the buildings. As the population increased, however, food became scarce.

☐1. What might have caused this food shortage to occur?

When the number of mice became greater than the 250 grams of food per day could support, some mice left the colony. Emlen found that the rate of emigration (mice leaving the colony) was about the same as the birthrate.

☐2. What does this experiment suggest about the effect of food supply on size of population?

☐3. Is the rate of emigration a controlling variable on size of population? Why?



Experiment B

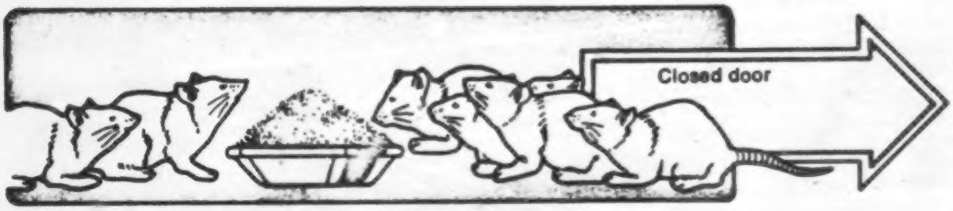
Dr. Emlen and his associates then performed a similar experiment, except that the mice were kept from emigrating. As before, the population increased. In this case, however, when the food shortage developed, the birthrate went down. The population stopped increasing.

☐4. Based on the results of this experiment and Experiment A, how does food supply affect the rate of emigration? What evidence supports your answer?

☐5. What was the relationship between food supply and birthrate when emigration was prevented?

Experiment C

A third experiment was conducted. As in Experiment B, emigration was prevented. But this time a lot of food was provided. As the population increased, the space per mouse decreased. There was less and less space for nests.



During this experiment, the number of mice increased rapidly at first until the mice became crowded. Then fighting and cannibalism shot up sharply. In addition, the females stopped taking proper care of their nests and their young. The death rate among the young reached 100 percent. The birthrate, however, remained high.

☐**6.** Summarize the effects of crowding on Emlen's mice.

☐**7.** How was the size of the population kept in balance?

Experiments similar to Emlen's have been done many times, usually with similar results. However, in some experiments, fighting and cannibalism did not exist. Instead, the mouse population increased until it reached a maximum size. Then all reproduction stopped.

In all these experiments, the size of the population reached a peak and then leveled off. This was true despite the fact that available food and space could have supported a much larger population. In some cases, the controlling variable was a high death rate. In the others, the controlling variable was a low birthrate.

☐**8.** Can you suggest some reasons why these populations became balanced by widely different means?

☐**9.** What variables might not have been carefully controlled in these two experiments?

Well, you've seen that crowding affects mice in some definite ways. Some of these ways are listed below:

1. The population leveled off well below the number of mice that the environment could support.
2. Either infant death rate was very high or there was a low birthrate.
3. Very unusual patterns of behavior in the mice became common.

What does this have to do with humans? That's for you to decide. Think through these experiments very carefully, imagining humans living in crowded city or ghetto conditions.

☐**10.** If mice could be compared to humans, what do the mice experiments predict about human behavior under crowded conditions? (Record your ideas in your Record Book.)

Emlen's experiments may suggest a procedure for doing your own population study. It can be a very interesting undertaking, but it takes careful planning, good experimental techniques, and much patience. Here are a few key questions you must be able to answer before you begin such an investigation:

1. What organism would it be convenient for me to study? Should it be a microorganism, an insect, a fish, a snail, a bird, or what?
2. How can I care for a population of the organism I choose? Can I study it in its natural environment? Or do I need to provide it with a new home? What kind of food must I provide?
3. What variables do I want to investigate?
4. How can I control the environment to study the effects of my variables?
5. For how long should I continue the investigation?
6. How do I count the individuals within the population?
7. What kind of records should I keep?

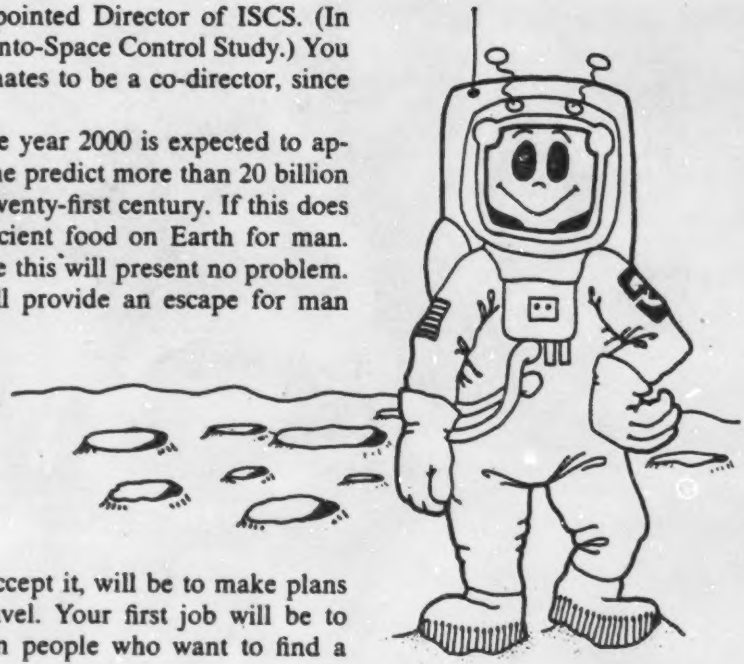
There are many other questions you can ask, of course. These are suggested to alert you to be careful in your planning. Think the problem all the way through before you start. When you have your teacher's okay for your plan, you can begin. Keep a good record in your Record Book so that you can report your findings to your teacher and classmates.

Escape into Space

Excursion 7-2

In this excursion you are appointed Director of ISCS. (In this instance, ISCS stands for Into-Space Control Study.) You may invite one of your classmates to be a co-director, since your new job is enormous.

The world population in the year 2000 is expected to approach 7.5 billion people. Some predict more than 20 billion people by the middle of the twenty-first century. If this does occur, there may not be sufficient food on Earth for man. However, many people believe this will present no problem. They believe space travel will provide an escape for man to other planets.



Your mission, should you accept it, will be to make plans and preparations for such travel. Your first job will be to handle the mail arriving from people who want to find a new home away from Earth.

As the new ISCS Director, you must write replies to the questions mailed to the Study by these people. Give each of these questions a brief, honest reply based on the information you find in Tables 1, 2, and 3. And use your own best judgment.

Questions 1 through 11 are taken from the letters. Answer each one carefully, and you will soon be an expert on space travel.

Table 1

TRAVEL GUIDE FOR THE PLANETS

Planet	Average Distance from Sun (miles)	Rotation Period (Earth Units)	Length of Year (Earth Units)	Diameter (miles)
Mercury	36,000,000	59 days (approx.)	88.0 days	3,000
Venus	67,000,000	249 days (approx.)	224.7 days	7,600
Earth	93,000,000	23.9 hours	365.3 days	7,900
Mars	142,000,000	24.6 hours	687.0 days	4,200
Jupiter	486,000,000	9.8 hours	11.9 years	89,000
Saturn	892,000,000	10.2 hours	29.5 years	75,000
Uranus	1,800,000,000	10.8 hours	84.0 years	30,000
Neptune	2,800,000,000	15 hours	164.8 years	28,000
Pluto	3,700,000,000	6.4 days	248.4 years	3,600

Table 2

CONDITIONS ON THE PLANETS

Planet	Mass Relative to Earth	Equivalent Weight of 150-lb person	Composition Of Atmosphere	Approximate Temperature (°C)
Mercury	0.05	55	carbon dioxide	One side 321° Other side −268°
Venus	0.81	130	nitrogen? carbon dioxide, water	Over 260°
Earth	1.00	150	nitrogen, oxygen, water, carbon dioxide, argon	From −87° to +58°
Mars	0.11	55	carbon dioxide, nitrogen? water	Midday 21° Sunset −18° Night −34°
Jupiter	317.8	380	hydrogen, helium, methane, ammonia, water? neon?	Average −129°
Saturn	95.2	160	Similar to Jupiter	Average −143°
Uranus	14.5	155	hydrogen, helium, methane, ammonia? water? neon?	Average −184°
Neptune	17.2	210	Similar to Uranus	Average −194°
Pluto	0.8 (approx.)	Unknown	Unknown	Average −212°

Table 3

TRAVEL GUIDE FOR THE PLANET MOONS

Planet	Known Satellites (in order of distance from planet)	Average Distance from Planet (miles)	Orbital Time (Earth days)	Approximate Diameter (miles)
Mercury	None			
Venus	None			
Earth	Moon	240,000	27.3	2,200
Mars	Phobos	5,800	0.3	5
	Deimos	15,000	1.3	3
Jupiter	V	110,000	0.5	70
	I (Io)	260,000	1.8	2,000
	II (Europa)	420,000	3.6	1,800
	III (Ganymede)	670,000	7.2	3,100
	IV (Callisto)	1,200,000	16.7	2,800
	VI	7,100,000	251	50
	VII	7,300,000	260	20
	X	7,400,000	264	10
	XII	13,000,000	631	10
	XI	14,000,000	692	10
	VIII	14,600,000	739	10
	IX	14,700,000	758	10
Saturn	Janus	100,000	0.8	Unknown
	Mimas	120,000	0.9	300
	Enceladus	150,000	1.4	400
	Tethys	180,000	1.9	630
	Dione	240,000	2.7	550
	Rhea	330,000	4.5	950
	Titan	760,000	15.9	3,000
	Hyperion	920,000	21.3	100
	Iapetus	2,200,000	79.3	500
	Phoebe	8,100,000	550	100
Uranus	Miranda	77,000	1.4	200
	Ariel	120,000	2.5	500
	Umbriel	170,000	4.2	350
	Titania	270,000	8.7	600
	Oberon	360,000	13.5	500
Neptune	Triton	220,000	5.9	2,300
	Nereid	3,500,000	359	200
Pluto	None			

☐**1.** My friends say it is too hot to be closer than 50 million miles to the sun. They also say that it is too cold to be more than 150 million miles away from the sun. My doctor says I should avoid extremes of cold and heat. Which planets (not Earth, for goodness sake!) could I move to?

☐**2.** I've seen how the astronauts carry their own oxygen around. I don't think I want to carry oxygen tanks on my back. Which planet should I go to so that I won't need to carry my own oxygen?

☐**3.** I can't get all my work done in 24 hours each day. Which planet would give me the longest day?

☐**4.** I told your ticket agent I would buy passage if he could send me to a place whose day is longer than its year. He said he could, but he didn't say to what planet. Where is he sending me?

☐**5.** I am twenty years old and anxious to live on Mars. Your agent tells me I will have to change my age to Mars' years. What is my Mars' age?

☐**6.** By careful dieting I have kept my weight at 100 pounds. Your agent said I would be heavier on Jupiter. What will be my Jupiter weight?

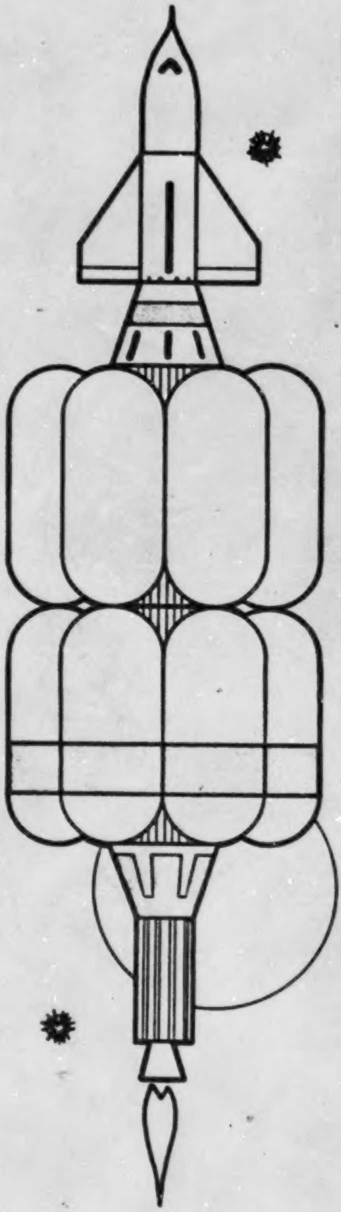
☐**7.** Which of all the planets, except Earth, has the most oxygen in its air?

☐**8.** I asked in my last letter how fast your spaceships are. You replied that they could travel up to 25,000 mph. How long will it take to get to Neptune?

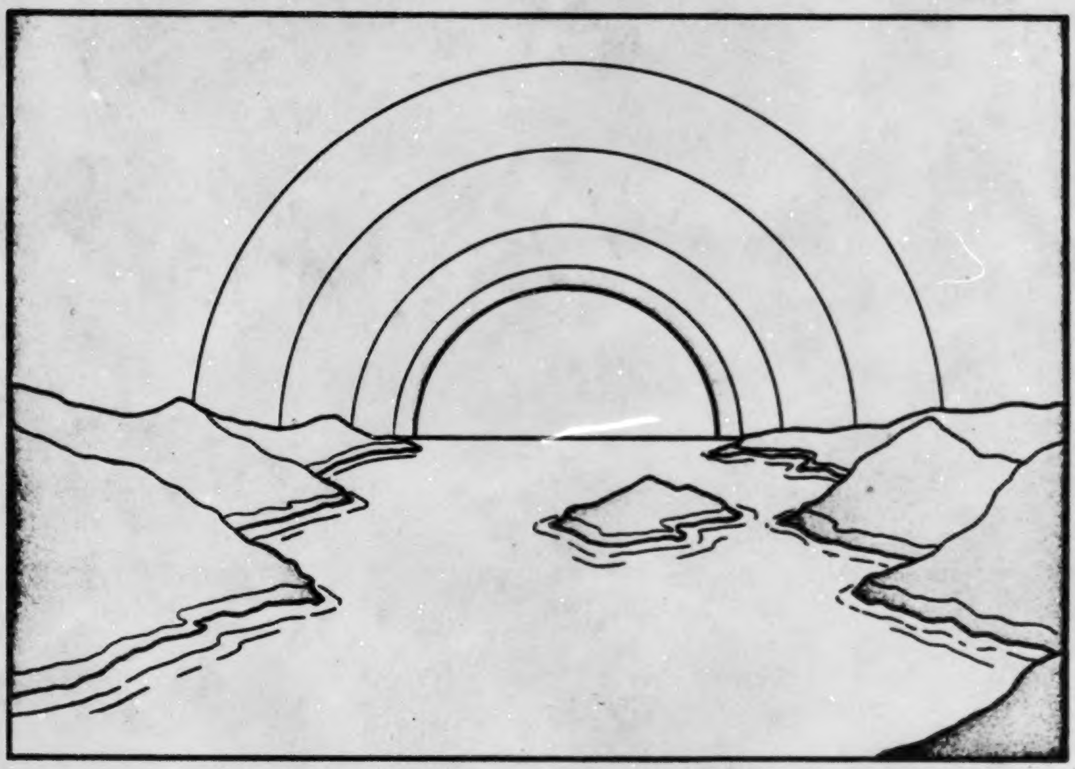
☐**9.** My ticket is marked "To the land of twelve moons, one way only." To which planet will this ticket take me?

☐**10.** Why won't your ticket agent sell me a ticket to one of Mercury's moons?

☐**11.** My husband wants to send me to Nereid on a separate vacation. How big is Nereid compared to Earth?
About how far is Nereid from the sun?
How far is Nereid from Earth?
At a speed of 25,000 miles per hour, how long will my trip take, one way?
At ten cents per mile, what is it going to cost me?



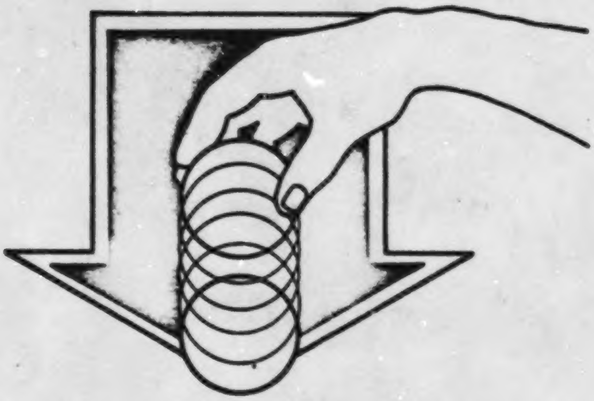
After writing answers to these questions, you should be ready to describe a planet or satellite that would be suitable for human habitation. Here are two specifications for such a planet:



1. To be habitable, any planet or satellite must have liquid water (not ice or water vapor alone). Let's assume that throughout the universe, water freezes at 0°C and vaporizes at 100°C. Therefore, any planet we want to live on must have temperatures within this range.

☐**12.** Which planets have part-time temperatures within this range?

2. To be habitable, any planet or satellite must have enough gravity to hold gases so that there will be an atmosphere. Among these gases, there must be oxygen. Gases like methane and ammonia are poisonous to humans.



☐13. Which planet, other than Earth, has oxygen in its atmosphere?

With this information, you should see that your assignment cannot be carried out. There is no place in our solar system that will support populations of humans unless you provide them with an artificial environment.

Wait! Don't close down your operations! Maybe you can send emigrants to planets belonging to other stars.

The nearest star (besides the Sun) is 4.3 light-years away. You may remember that a light-year is the distance that would be traveled if your vehicle were moving at 186,000 miles per second (the speed of light) for one whole year. This distance is about three and a half trillion miles.

Since our present spaceships travel about 6 miles/sec, it would take 600 billion seconds to reach the nearest star. That is about 20,000 years one way.

☐14. Do you believe moving people to other planetary systems will be an answer to the world's population-explosion problems?

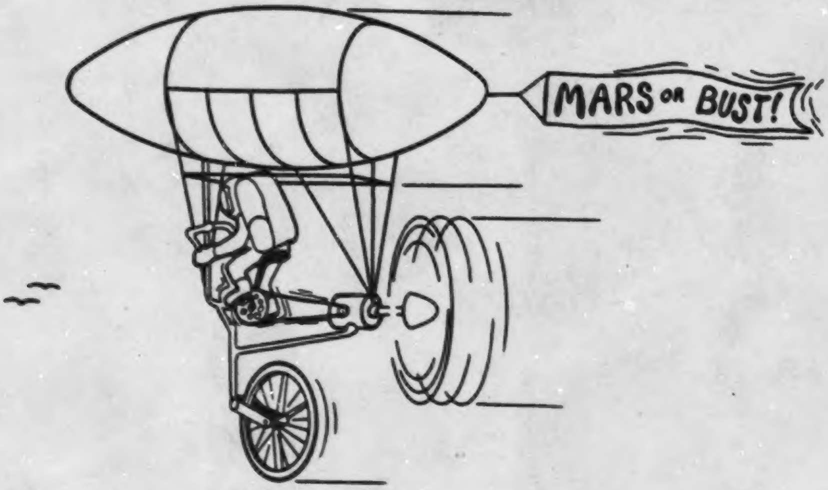
Let's be very optimistic as we look at the problem from another standpoint. The vehicle that carries three Americans to the moon on each trip is called Apollo. Suppose Apollo could carry 100 people to one of the planets for the same cost as that of carrying three men to the moon. Assuming no change in the growth rate, we would have to export about 70,000,000 people per year in order to hold the present world population constant.

☐**15.** How many people would have to leave Earth daily?

☐**16.** How many 100-passenger spaceships would have to leave Earth daily?

The cost would exceed $300,000,000,000 daily, not counting any expenses involved in training the migrants or in preparing a new home for them.

It appears that you will have to resign your job. On the basis of what you know now, you can't move people to new homes on some other planet. Your job is impossible. If your boss doesn't believe your job is impossible, ask him to take this excursion. If you don't know who your boss is, how did you get appointed as Director of ISCS?


MARS OR BUST!

Birthday Control

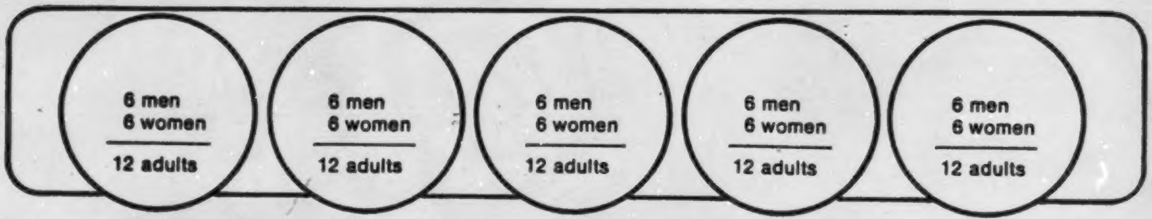
Excursion 7-3

Some people believe there is only one way to avoid the bad environmental effects of the human population explosion. They argue that the birthrate must be decreased to match the death rate. To accomplish this, they insist that parents must take responsibility for keeping their families small.

Such suggestions are not well received by a number of the citizens of the United States. For example, some 40 percent of United States adults believe an ideal family includes four or more children. Is that too large a number if the birthrate is to match the death rate? This excursion will help you decide for yourself.

Suppose there are five sets of parents. In each set there are 12 adults (6 couples). See Figure 1.

Figure 1


6 men
6 women
12 adults
Set 1
6 men
6 women
12 adults
Set 2
6 men
6 women
12 adults
Set 3
6 men
6 women
12 adults
Set 4
6 men
6 women
12 adults
Set 5

Suppose each set of couples has a different idea as to what is the best family size.

Set 1 prefers having one child per couple.
Set 2 prefers having two children per couple.
Set 3 prefers having three children per couple.
Set 4 prefers having four children per couple.
Set 5 prefers having five children per couple.

Assume that the children, grandchildren, and so on, of each set of parents agree with the original parents on an ideal family size. Using Table 1, calculate the size of the population that results from each set of parents for the next four generations. Assume that at the end of each generation, only the children of that generation are alive (all parents dead). Also, assume that each generation has about an equal number of men and women.

If you come up with an odd number of people in any generation, consider the unpaired individual to be childless.

Table 1

POPULATION CHANGES

Parent Set	Generation				
	Parent	2nd	3rd	4th	5th
1	12				
2	12				
3	12				
4	12				
5	12				

☐**1.** Which of the parent sets will produce an increasing population?

☐**2.** Which of the parent sets will produce a population of steady size?

☐**3.** Which of the parent sets will produce a decreasing population?

Graph the information from Table 1 in Figure 2 of your Record Book. Draw a separate line or curve for each parent set. Label each.

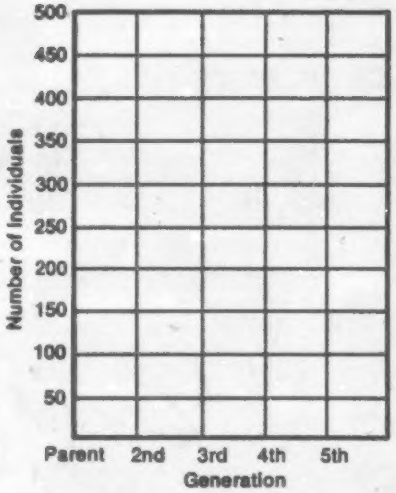
☐**4.** Which of the curves in Figure 2 resembles the world population curve you drew in Figure 7-1 of Chapter 7?

Suppose you agree with those who argue that the birthrate must not exceed the death rate.

☐5. Based on Table 1, what number of children would you recommend for each family?

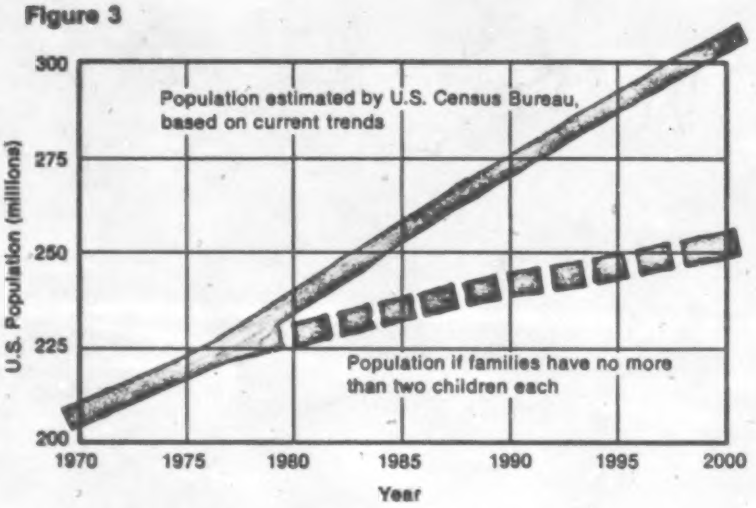
☐6. What effects would unexpected increases in the death rate have if this method of birth control were used?

Figure 2



Do you believe it would really make any difference if there were a reduction in family size in the United States? Study Figure 3 to find the answer.

Figure 3



☐7. If present trends continue, what will the United States population be in the year 2000?

☐8. If, beginning in 1970, families were to have no more than two children each, what would the United States population be in the year 2000?

☐9. What is the difference (in millions of people) between your answers to questions 7 and 8?

The assumption you made earlier about all parents dying, is of course not true in the United States. It is quite common for several generations (grandparents, parents, children, etc.) to be alive at the same time. One reason for this is people are living longer each generation. Study Table 3 to see what has been happening to life expectancy throughout history.

Region and Time	Life Expectancy
Neanderthal Man	29
Classical Greece	35
Classical Rome	32
England, 14th Century	38
England, 19th Century	41
United States, 1900	50
United States, 1940	61
United States, 1970	72

Table 3

☐**10.** What reasons can you give for the increasing life span of humans?

☐**11.** Based upon the trend in Table 3, what do you predict will be the life expectancy for a child born in the year 2000?

Well, there are more and more people, and their individual life-spans are increasing.

☐**12.** What do you see as the strongest reasons for birth control?

☐**13.** What do you think are the strongest reasons against birth control?

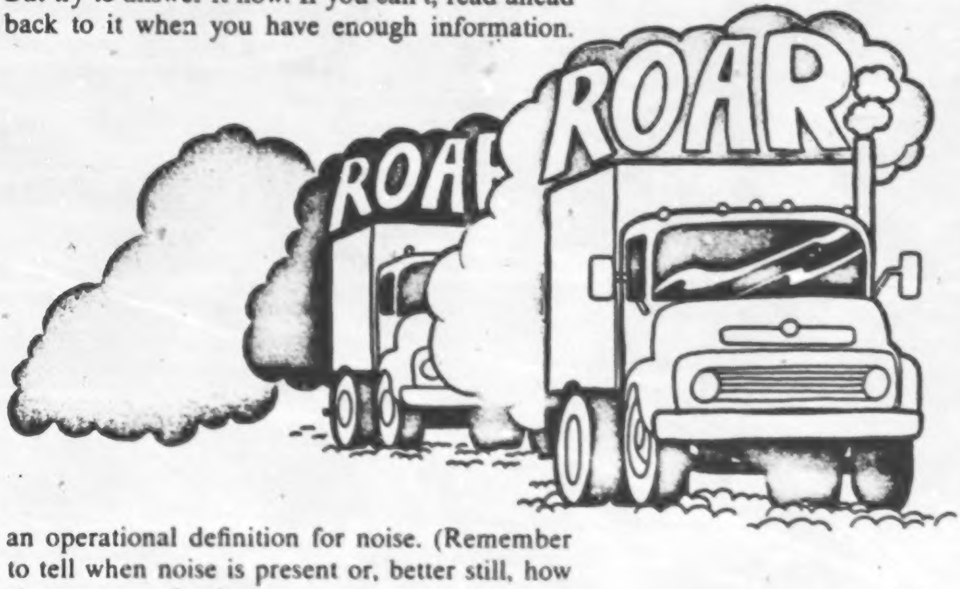
Discuss your answers to questions 12 and 13 with some of your classmates.

Ssh! You're Polluting the Environment

Excursion 8-1

"My, but it's quiet" is the kind of comment that people who leave a city or town often make. Noise is so much a part of our environment that we tend to ignore it—unless it's very loud or when it's not there. Stop reading and listen for a few moments. Yours is a quiet classroom if you don't hear a dozen or more different kinds of sounds within a few minutes.

All noise is sound, but is all sound noise? Different people probably define noise differently. The next question is a tough one. But try to answer it now. If you can't, read ahead and come back to it when you have enough information.



☐**1.** Write an operational definition for noise. (Remember to tell how to tell when noise is present or, better still, how to measure the amount of noise.)

Extremely loud sounds, such as explosions, can cause deafness. But most people never hear sounds that loud. In order to see the effect of more common and less loud sounds, you need to know how sound is measured.

The loudness of sound is measured in *decibels.* Zero on the decibel scale is the quietest sound that can be heard by the best ears. Table 1 shows the decibel value for some common sounds.

Table 1

Category of Sound	Loudness on Decibel Scale	Type of Noise
Threshold of Hearing	0–10	Rustling leaves. Light breathing.
Faint	10–25	Whisper at two meters. Quiet office. Empty movie house. Quiet neighborhood at night.
Moderate	25–50	Suburban playground. Restaurant. Average living room. People talking.
Loud	50–70	City playground. Vacuum cleaner. Noisy office. Average traffic.
Very loud	70–90	Portable sander. Food blender. Noisy party. Power lawn mower. City traffic. Garbage disposal.
Deafening	90–115	Rock band. Loud motorcycle. Car horn at one meter. Airplane propeller at takeoff. Jackhammer. Foot of large waterfall. Subway train.
Painful to ear	115–130	Thunderclap. Distant rocket. Siren at two meters. Jet engine revving for takeoff.
Eardrum breaks	130 or more	Jet plane taking off. Rocket engine at close range. Explosions. Large weapons (cannons, machine guns, etc.).

☐**2.** According to Table 1, your classroom has about what decibel level?

As you may know, sound is also measured in frequency. The higher the frequency, the higher pitched the sound is.

☐**3.** Are high-pitched, or low-pitched, noises more annoying to you?

If you are like most people, high-pitched noises are more annoying to you. Of course, another variable is when a particular sound occurs. Most people can stand a much higher sound level during the day than they can at night.

☐**4.** What decibel level causes deafness from a single blast?

In answering the last question, you probably referred back to Table 1. The table tells you that the eardrum breaks when it receives sounds at a decibel level of 130 or more. When this happens, a person becomes deaf to most sounds. Take a look at Figure 1 and find the eardrum.

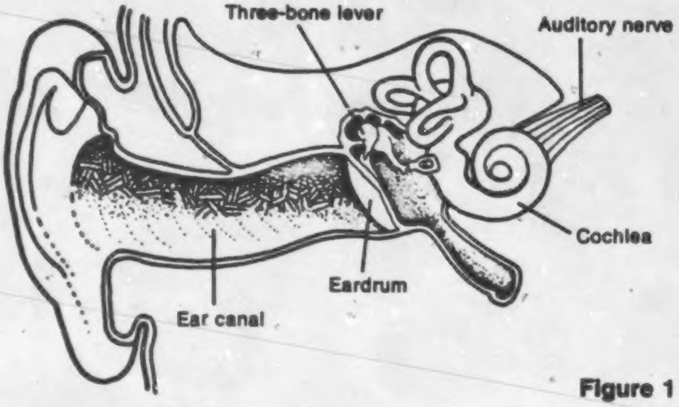


Figure 1

Sounds enter the ear canal and strike the eardrum, causing it to vibrate. These vibrations are carried by three tiny bones to a second membrane in the inner ear. Vibrations of this membrane cause movements in the liquid of the snail-shaped cochlea. When tiny hairs are shaken by the vibrating liquid, nerve messages are sent to the brain.

Many studies have been done on the hearing of Americans. The average hearing ability of people is defined as "standard." Hearing loss is measured by comparing a person's hearing ability with the standard. If, for example, a sound must be 15 decibels above the standard for a person to hear it, he is said to have a 15-decibel hearing loss.

☐**5.** Describe the hearing of a person who can hear a sound only when it is 43 decibels above the standard.

☐**6.** Describe the hearing of a person who can hear a sound when it is 6 decibels below the standard.

Figure 2 shows the changes in hearing that can occur from being in a noisy environment (90 decibels) for a long time.

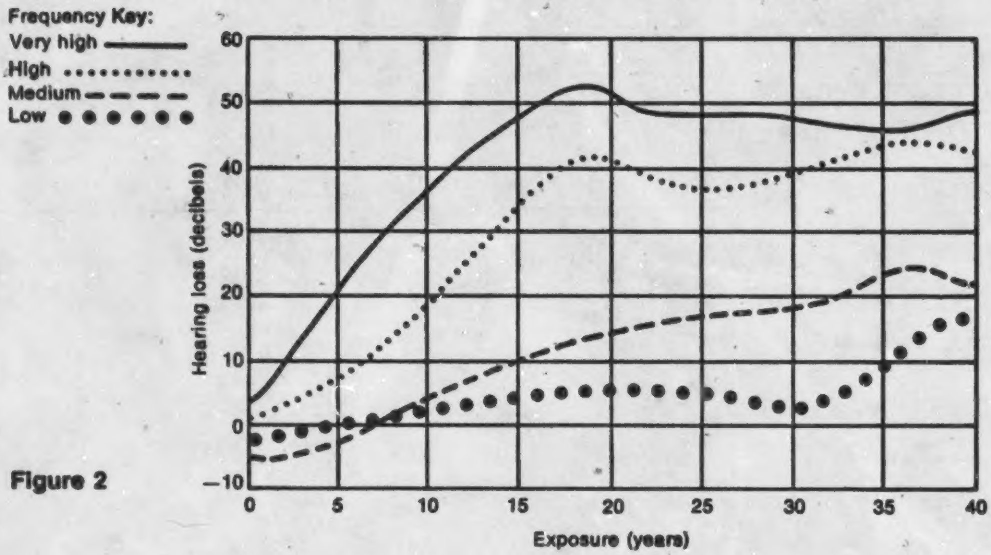


Figure 2

☐**7.** Is there a greater hearing loss at low, or at high, frequencies?

☐**8.** Do hearing losses develop at low frequencies faster, or slower, than they do at high frequencies?

☐**9.** What kinds of occupations might commonly have a 90-decibel environment?

Most people suffer some hearing loss as they get older, especially for high-frequency sounds. However, being in a noisy environment while aging can make the loss greater. Figure 3 shows the standard hearing loss for high sound frequencies.

☐**10.** How would you describe the hearing loss of an average 65-year-old person compared to the average 23-year-old?

Studies have shown that over an eight-hour working day few humans can stand more than 80 to 90 decibels of sound.

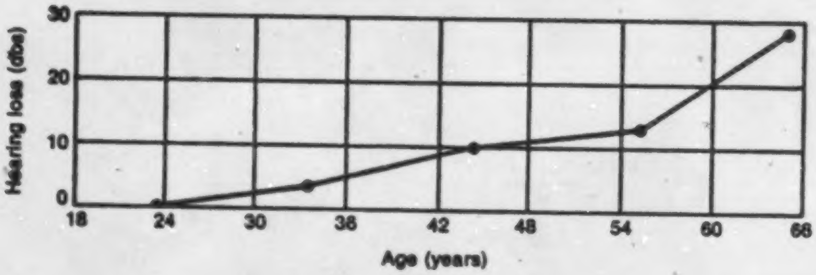


Figure 3

Workers in noisy environments often wear plugs, earmuffs, and other ear protectors. But since this practice started only about twenty years ago, many people are partially deaf who shouldn't be.

Noise has been blamed for high blood pressure, indigestion, social conflicts, high divorce rate, and many other problems. There is a good deal of evidence that sound can cause psychological as well as physical damage. Near large airports some schools have had to be closed because the noise made it hard for the students to think.

In several chapters in this unit, you have studied how the output of automobiles pollutes the atmosphere.

Automobiles and trucks are noise polluters. In fact, they are probably the greatest of all noise polluters. Traffic noise is at or near the top of the list of noises that most people would like to eliminate. Table 2 shows the average noise levels of cars and trucks at a distance of about eight meters from a California superhighway.

Table 2

Noise Source	Average Decibel Level
Automobile, 48 km/hr (30 mph)	68
Automobile, 113 km/hr (70 mph)	81
Trucks, 80 km/hr (50 mph)	105

☐**11.** What is the effect of a car's speed on its noise production?

☐**12.** How does the noise level produced by trucks at 80 km/hr compare with the noise level of propeller-driven airplanes at takeoff?

Reducing the level of sound in our environment is not an easy task. Some people seem to prefer noise, even if it may mean that they will eventually suffer some hearing loss.

PICTURE CREDITS

x	The Bettmann Archive, Inc.
6	Susan Johns from Rapho Guillumette Pictures
20	Bruce Roberts from Rapho Guillumette Pictures
30	David Hurn from Magnum
38	Courtesy Environmental Protection Agency
44	Arthur Tress from Photo Trends
58	Elliott Erwitt from Magnum
72	Bruce Roberts from Rapho Guillumette Pictures
73	Frederic Lewis
79	UNICEF
82	Bruce Davidson from Magnum
94	Courtesy ISCS